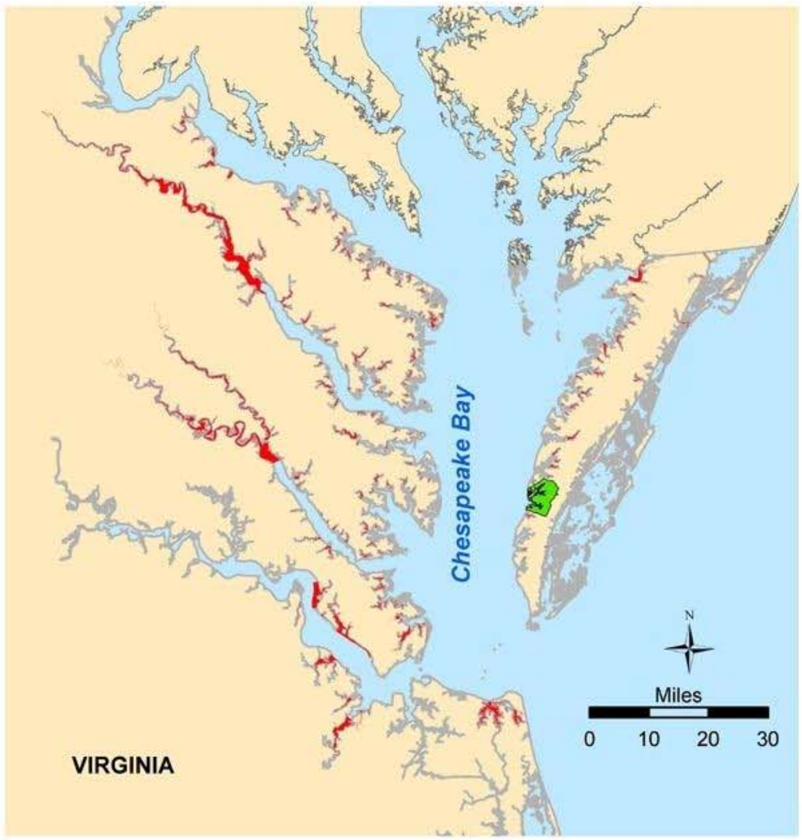
Total Maximum Daily Load (TMDL) Report for Shellfish Areas Listed Due to Bacterial Contamination

Barlow and Jacobus Creeks



VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

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Barlow Creek and Jacobus Creek Total Maximum Daily Load (TMDL) Report for Shellfish Condemnation Areas Listed Due to Bacteria Contamination

Virginia Department of Environmental Quality

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Table of Contents

Table of Contents

List of Figures and Tables

List of Figures and Tables

Total Maximum Daily Load Executive Summary

Total Maximum Daily Load Process

Management of water quality is a process intended to protect waters for a variety of uses. The first step in the process is the identification of desired uses for each water body. There are typically a number of physical, chemical and/or biological conditions that must exist in a water body to allow for a desired use to exist. In Virginia, most inshore tidal waters are identified as potential shellfish growing waters. In order to support shellfish propagation without risk to human consumers, shellfish waters must have very low levels of pathogenic organisms. Virginia, as most other states, uses fecal coliforms (FC) as an indicator of the potential presence of pathogenic organisms. To maintain the use of a water body for direct shellfish harvesting, the goal is to ensure the concentration of fecal coliforms entering the water body does not exceed a "safe" level. The safe level is set as the standard against which water quality monitoring samples are checked.

When water quality monitoring detects levels of fecal coliforms above allowable, "safe" levels, managers must identify the potential sources and plan to control them. The prescribed method for figuring out what must be controlled to attain the water quality standard is the calculation of a total maximum daily load (TMDL). The TMDL is the amount of fecal coliforms that may be introduced by each potential source without exceeding the water quality standard for fecal coliforms in shellfish growing waters.

The process of developing a shellfish water TMDL may be generalized in the following manner:

1. Water quality monitoring data are used to determine if the bacterial standard for shellfish have been violated;
2. Potential sources of fecal bacteria loading within the contributing watershed are identified;
3. The necessary reductions in fecal bacteria pollutant load to achieve the water quality standard are determined;
4. The TMDL study is presented to the public to garner comment;
5. An implementation strategy to reduce fecal bacteria loads is written into a plan and subsequently implemented;
6. Water quality monitoring data are used to determine if the bacterial standard is being met for shellfish waters.

Different approaches can be used to determine the sources of fecal pollution in a water body. Two distinctly different approaches are watershed modeling and bacterial source tracking (BST). Watershed modeling begins on the land, identifying potential sources based on information about conditions in the watershed (e.g. numbers of residents, estimated wildlife populations, estimated of livestock, etc.). BST begins in the water, identifying sources of fecal coliforms, specifically the dominant fecal coliform *Escherichia coli*, to shellfish waters based on either genetic or phenotypic characteristics of the coliforms. Virginia's Department of Environmental Quality has decided to utilize BST, and specifically to use a method called antibiotic resistance analysis (ARA). This method assumes that fecal bacteria found in four sources: humans, wildlife, livestock, and domestic animals will all differ in their reactions to antibiotics. Thus, when samples of fecal bacteria collected in the water quality monitoring program are exposed to specific antibiotics the pattern of responses allows matching similarities to the response patterns of bacteria from known sources which have been accumulated in a "source library". Through this analysis investigators also estimate the relative proportion of the fecal bacteria derived from each of the four general source classes and assumes this proportion reflects the relative contribution from the watershed. The resulting estimates of the amount of fecal coliform pollution coming from each type of source can then be used to allocate reductions necessary to meet the water quality standard for shellfish growing waters. Identifying and agreeing on the means to achieve these reductions represent the TMDL implementation plan. Continued water quality monitoring will tell whether the efforts to control sources of fecal coliforms in the watershed have succeeded.

Fecal Coliform Impairment

This document details the development of bacterial TMDLs for two impairments in the Barlow and Jacobus Creek Watersheds, tributaries to the Chesapeake Bay identified as sub-watersheds within shellfish Growing Area 86. These impairments were identified in the 1998 303(d) list as Jacobus Creek **(**VAT-C14E-12) condemnation 86-136B (formerly 9B), and Barlow Creek (VAT-C14E-10) condemnation 86-136D (formerly 191) located in Northampton County, Virginia. The former Jacobus Creek segment 9E, now identified as segment 86-136E, is a permanently prohibited shellfish harvest zone as a buffer for a VPDES point source discharge and there is no shellfish use for this segment. It will therefore no longer be listed on the 303(d) list as impaired and is not covered in this TMDL. The VDH-DSS impairment identification nomenclature for these TMDL segments was changed in the January 2006 Shellfish Closure Notice. The current Condemnation Notice can be found in **Appendix A**.

The applicable state standard specifies that the number of fecal coliform bacteria shall not exceed a maximum allowable level of a Geometric Mean of 14 MPN/100mL (Most Probable Number per 100 milliliters water) and a 90^{th} Percentile value of 43 MPN/100mL for a 5-tube, 3-dilution test or 49 MPN/100mL for a 3-tube, 3-dilution test (Virginia Water Quality Standard 9-VAC 25-260-160). In development of this TMDL, the 90^{th} Percentile 49 MPN/100 mL was used, since it represented the more stringent standard.

Sources of Fecal Coliform

Potential sources of fecal coliform consist primarily of non-point source contributions, as there are no permitted point source discharges that directly impact the identified impairments in the watershed. Non-point sources include wildlife; livestock; land application of bio-solids; recreational vessel discharges; failed, malfunctioning, or non-operational septic systems, and uncontrolled discharges (straight pipes conveying gray water from kitchen and laundry areas of private homes, etc.).

Water Quality Modeling

A simple volumetric model was used for this TMDL study because the character of the water bodies to be modeled is relatively simple from a hydrologic perspective: for example, small in area and volume with a single, unrestricted connection to receiving waters. This approach uses the volume of the water and pollutant concentration in order to establish the existing and allocation conditions.

Determination of Existing Loadings

To assist in partitioning the loads from the diverse sources within the watershed, water quality samples of fecal coliform bacteria were collected for one year and evaluated using an antibiotic resistance analysis in a process called bacterial source tracking. These samples were compared to a reference library of fecal samples from known sources. The resulting data were used to assign portions of the load within the watershed to wildlife, humans, pets or livestock. The results of this analysis indicated that the primary source of fecal coliforms is human with livestock and pets as secondary contributors. The presence of a large signature attributable to one component is sufficient to establish potential directions for remediation under a future implementation plan.

Load Allocation Scenarios

The next step in the TMDL process was to determine the appropriate water quality standard to be applied. This was set as the 90th Percentile standard because the data established that the 90th Percentile required the greater reduction. Calculated results of the model for each segment were used to establish the existing load in the system. The load necessary to meet water quality standards was calculated in a similar fashion using the water quality standard criterion in place of the ambient water quality value. The difference between these two numbers represents the necessary level of reduction in each segment.

Finally, the results of the BST developed for each segment were used to partition the load allocation that would meet water quality standards according to source. The results of the model and the reductions necessary for each segment are shown below.

Geometric Mean Analysis of Current Load and Estimated Load Reduction

Condemnation Area	Volume (m^3)	Fecal Coliform (MPN/100ml)	WQ Standard (MPN/100 mL)	Current Load (MPN/day)	Allowable Load (MPN/day)	Required Reduction
Barlow Creek 86-136D (VAT-C14E-10)	25560	19.4	14	4.96E+09	3.58E+09	28%
Jacobus Creek* 86-136B (VAT-C14E-12)	345960	44.9	14	1.55E+11	4.84E+10	69%

90th Percentile Analysis of Current Load and Estimated Load Reduction

Condemnation Area	Volume (m^3)	Fecal Coliform (MPN/100ml)	WQ Standard (MPN/100mL)	Current Load (MPN/day)	Allowable Load (MPN/day)	Required Reduction
Barlow Creek 86-136D (VAT-C14E-10)	25560	148.6	49	3.80E+10	1.25E+10	67%
Jacobus Creek* 86-136B (VAT-C14E-12)	345960	398	49	1.38E+12	1.70E+11	88%

* Jacobus Creek formerly listed two segments as impaired 9D (currently 136B) and 9E. 9E is a permanently prohibited shellfish harvest zone and has no shellfish use. It is therefore de-listed for the purposes of the section 303(d) impaired waters list.

Margin of Safety

In order to account for uncertainty in modeled output, a margin of safety (MOS) was incorporated into the TMDL development process by making very conservative choices. A MOS safety can be incorporated implicitly in the model through the use of conservative estimates of model parameters, or explicitly as an additional load reduction requirement. Individual errors in model inputs, such as data used for developing model parameters or data used for calibration, may affect the load allocations in a positive or a negative way. The purpose of the MOS is to avoid an overall bias toward load allocations that are too large for meeting the water quality target. An implicit MOS was used in the development of this TMDL through selection of a water quality standard providing a high level of protection, utilization of entire segment volumes for model calculations, use of extreme high values to ensure that the more protective condition with the largest available data set was addressed and emphasizing watershed-based implementation measures.

Recommendations for TMDL Implementation

The goal of this TMDL was to develop an allocation plan that achieves water quality standards during the implementation phase. Virginia's 1997 Water Quality Monitoring, Information and Restoration Act states in section 62.1-44.19.7 that the "Board shall develop and implement a plan to achieve fully supporting status for impaired waters".

The TMDL developed for these impairments, provide allocation scenarios that will be a starting point for developing implementation strategies. Additional monitoring aimed at targeting the necessary reductions is critical to implementation development. Once established, continued monitoring will aid in tracking success toward meeting water quality milestones.

Public participation is critical to the implementation process. Reduction in non-point source loading is the crucial factor in addressing the problem. These sources cannot be addressed without public understanding of and support for the implementation process. Stakeholder input will be critical from the onset of the implementation process in order to develop an implementation plan that will be truly effective.

Public Participation

During development of the TMDL for the Jacobus Creek and Barlow Creek in Growing Area 86, public involvement was encouraged through a public participation process that included public meetings and stakeholder meetings.

The first public meeting was held on February 6, 2007. A basic description of the TMDL process and the agencies involved was presented and a discussion was held to regarding the source assessment input, bacterial source tracking, and model results. This meeting was followed by development of the final draft TMDL and a review by the stakeholders. Input from this meeting was utilized in the development of the TMDL and improved confidence in the allocation scenarios and TMDL process.

The second public meeting was held on April 14, 2007. The results of the TMDL study were presented and discussed. Public participation and involvement in the TMDL implementation planning process was encouraged.

1.0 Introduction

This document details the development of a bacterial Total Maximum Daily Load (TMDL) for one segment in each of Jacobus Creek and Barlow Creek in Growing Area 86 located in Northampton County, Virginia. These two waters are listed as impaired on Virginia's 303(d) Total Maximum Daily Load Priority List. The condemnations for Hungers and Mattawoman Creeks also found in this growing area are addressed in a separate report. The TMDL is one step in a multi-step process that includes a high level of public participation in order to address water quality issues that can affect public health and the health of aquatic life.

1.1 Listing of Water Bodies Under the Clean Water Act

Water quality standards are regulations based on federal or state law that set numeric or narrative limits on pollutants. Water quality monitoring is performed to measure these pollutants and determine if the measured levels are with the bounds of the limits set for the uses designated for the water body. The water bodies which have pollutant levels above the designated standards are considered impaired for the corresponding designated use (e.g. swimming, drinking, shellfish harvest, etc.). The impaired waterways are listed on the §303 (d) list reported to the Environmental Protection Agency. Those waters placed on the list require the development of a TMDL intended to eliminate the impairment and bring the water into compliance with the designated standards.

TMDLs represent the total pollutant loading that a water body can receive without violating water quality standards. The TMDL process establishes the allowable loading of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (EPA, 1991).

Fecal coliform bacteria are the most common cause for the impairments in Virginia shellfish growing waters. This group of bacteria is considered an indicator of the presence of fecal contamination. The most common member of the fecal coliform groups is *Escherichia coli*. Fecal coliforms are associated with the fecal material derived from humans and warm-blooded animals. The presence of fecal coliform bacteria in aquatic environments is an indication that the water may have been contaminated by pathogens or disease-producing bacteria or viruses. Waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis, and hepatitis A. Filter-feeding shellfish can concentrate these pathogens which can be transmitted and cause disease when eaten uncooked. Therefore, the presence of elevated numbers of fecal coliform bacteria is an indicator that a potential health risk exists for individuals consuming raw shellfish. Fecal contamination can occur from point source inputs of domestic sewage or from nonpoint sources of human, (e.g., malfunctioning septic systems) or animal wastes.

Because the fecal coliform indicator does not provide information on the source or origin of fecal contamination, Agencies of the Commonwealth, including the Department of Environmental Quality (DEQ), the Virginia Department of Health – Division of Shellfish Sanitation (VDH-DSS) and the Department of Conservation and Recreation (DCR) have worked together with state universities, the U.S. Geological Survey and the U.S. Environmental Protection Agency to develop methods to assess sources of fecal coliforms to assist in development of TMDLs in impaired shellfish waters.

As a group these methods are usually called Bacterial or Microbial Source Tracking (BST or MST). This study utilizes bacteria source tracking (BST) to determine the most probable sources of fecal coliform in the water.

1.2 Overview of the TMDL Development Process

A TMDL study for shellfish waters is the first part of a phased process aimed at restoring water quality. This study is designed to determine how much of the pollutant input needs to be reduced in order to achieve water quality standards. The second step in the process is the development of an implementation plan that identifies which specific control measures are necessary to achieve those reductions, their timing for implementation and at what cost. The implementation plan will also outline potential funding sources. The third step will be the actual implementation process. Implementation will typically occur in stages that allow a review of progress in reducing pollutant input, refine bacteria loading estimates based upon additional data and to make any identified changes to pollutant control measures.

The TMDL development process also must account for seasonal and annual variations in precipitation, flow, land use, and pollutant contributions. Such an approach ensures that TMDLs, when implemented, do not result in violations under a wide variety of scenarios that affect bacterial loading.

2.0 Applicable Water Quality Standard

Appropriate water quality standards are based on state and federal laws. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *"water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

2.1 Designated Uses and Criteria

Generally, most in-shore tidal waters in Virginia are designated as shellfish waters. The identification of the applicable river reaches can be found in the river basin tables at 9 VAC 25-260-390 et seq. For a shellfish supporting water body to be in compliance with Virginia bacterial standards, VADEQ specifies the following criteria (9 VAC 25-260-160): "*In all open ocean or estuarine waters capable of propagating shellfish or in specific areas where public or leased private shellfish beds are present, and including those waters on which condemnation or restriction classifications are established by the State Department of Health, the following criteria for fecal coliform bacteria shall apply; The Geometric Mean fecal coliform value for a sampling station shall not exceed an MPN (most probable number) of 14 per 100 milliliters. The 90th Percentile shall not exceed an MPN of 43 for a 5 tube, 3 dilution test or 49 for a 3 tube, 3 dilution test."*

2.2 Classification of Virginia's Shellfish Growing Areas

The Virginia Department of Health, Division of Shellfish Sanitation (VDH-DSS) is responsible for classifying shellfish waters and protecting the health of bivalve shellfish consumers. The VDH- DSS follows the requirements of the National Shellfish Sanitation Program (NSSP), which is regulated by the U.S. Food and Drug Administration. The NSSP specifies the use of a shoreline survey as its primary tool for classifying shellfish growing waters. Fecal coliform concentrations in water samples collected in the immediate vicinity of the shellfish beds function to verify the findings of the shoreline survey and to define the border between approved and condemned (unapproved) waters. Much of the VDH-DSS effort is focused on locating fecal contamination, and in this manner minimizing the introduction of human pathogens to shellfish waters.

VDH-DSS designs and operates the shoreline survey to locate sources of pollution within the watersheds of shellfish growing areas. This is accomplished through a property-by-property inspection of the onsite sanitary waste disposal facilities of most properties on un-sewered sections of watersheds, and investigations of other sources of pollution such as wastewater treatment plants (WTP), marinas, livestock operations, landfills, etc. The information is compiled into a written report with a map showing the location of the sources of real or potential pollution found and sent to the various agencies that are responsible for regulating these concerns in the city or county. Once an onsite problem is identified, local health departments (LHDs), and/or other state and local agencies may play a role in the process of correcting the deficiencies.

The VDH-DSS collects monthly seawater samples at over 2,000 stations in the shellfish growing areas of Virginia. Though they continuously monitor sample data for unusual events, they formally evaluate shellfish growing areas on an annual basis. The annual review uses data from the most recent 30 samples (typically 30 months), collected randomly with respect to weather. The data are assessed to determine whether the water quality standards are met. If the water quality standards are exceeded, the shellfish area is closed for the harvest of shellfish that go directly to market. Those areas that marginally exceed the water quality standard and are closed for the direct marketing of shellfish are eligible for harvest of shellfish under permit from the Virginia Marine Resources Commission and VDH-DSS. The permit establishes controls that in part require shellfish be allowed to depurate for 15 days in clean growing areas or specially designed licensed on shore facilities. Shellfish in growing areas that may be highly polluted, such as those in the immediate vicinity of a wastewater treatment facility (prohibited waters), are not allowed to be moved to clean waters for self purification.

3.0 Watershed Characterization

The TMDL for Shellfish Growing Area 86 includes the Jacobus and Barlow Creek Watersheds listed as impaired in 1998. These impaired waters are located entirely within Northampton County. The Growing Area 86 watershed is bounded on the north by Church Neck Road, on the west by the Chesapeake Bay, on the east by State Route 13, and the south by Old Town Neck Road. The location of the combined watershed is shown in **Figure 3.0**

The drainage areas of the individual watersheds are as follows: 1) Barlow Creek, 785.5 acres or 1.2 mi^2 and 2) Jacobus Creek, 2027.8 acres or 3.2 mi^2. The entire shellfish growing area 86 watershed has an estimated year round population according to the 2000 US Census of 839.

A map of the land use in each of these sub-watersheds is shown in **Figures 3-1A and 3.1B** and summarized in **Table 3.2**. In each of these watersheds the dominant land use type is forest, grassland and agriculture. Estimations of the populations of livestock and wildlife, as well as numbers of septic systems within the watershed are shown in **Table 3.1**. **Appendix B** provides a description of data and list of data sources for **Table 3.1**.

Table 3.1 Estimated Animal Populations and Septic Systems Growing Area 86

Fecal Coliform Sources	Barlow Creek 86-136D (VAT-C14E-10)	Jacobus Creek 86-136B (VAT-C14E-12)
Cattle	4	7
Chicken	1	1
Deer	56	124
Dog	26	116
Duck	101	199
Geese	70	137
Horse	1	2
Sheep	1	1
Pig	3	3
Raccoon	37	81
Septic	45	100

4.0 Water Quality Impairment and Bacterial Source Assessment

4.1 Water Quality Monitoring

The shellfish water quality monitoring network consists of a total of 32 stations for Shellfish Growing Area 86. This number may vary as the VDH-DSS adds and removes stations in order to provide necessary coverage to determine public health risks. The impaired shellfish waters, or condemnation areas are shown in **Figure 4.1**. In these waters there are three (3) monitoring stations for the impaired segment for Barlow Creek, and five (5) for Jacobus Creek. These stations are monitored by the VDH-DSS for fecal bacteria. The locations of the water quality monitoring stations are shown in **Figure 4.2**. At least one station in each of these watersheds was sampled for bacteria source tracking. These stations are also identified in **Figure 4.2**. This TMDL study examined bacterial monitoring data at these stations for a period of time from May of 2003 through December 2005. A summary of water quality

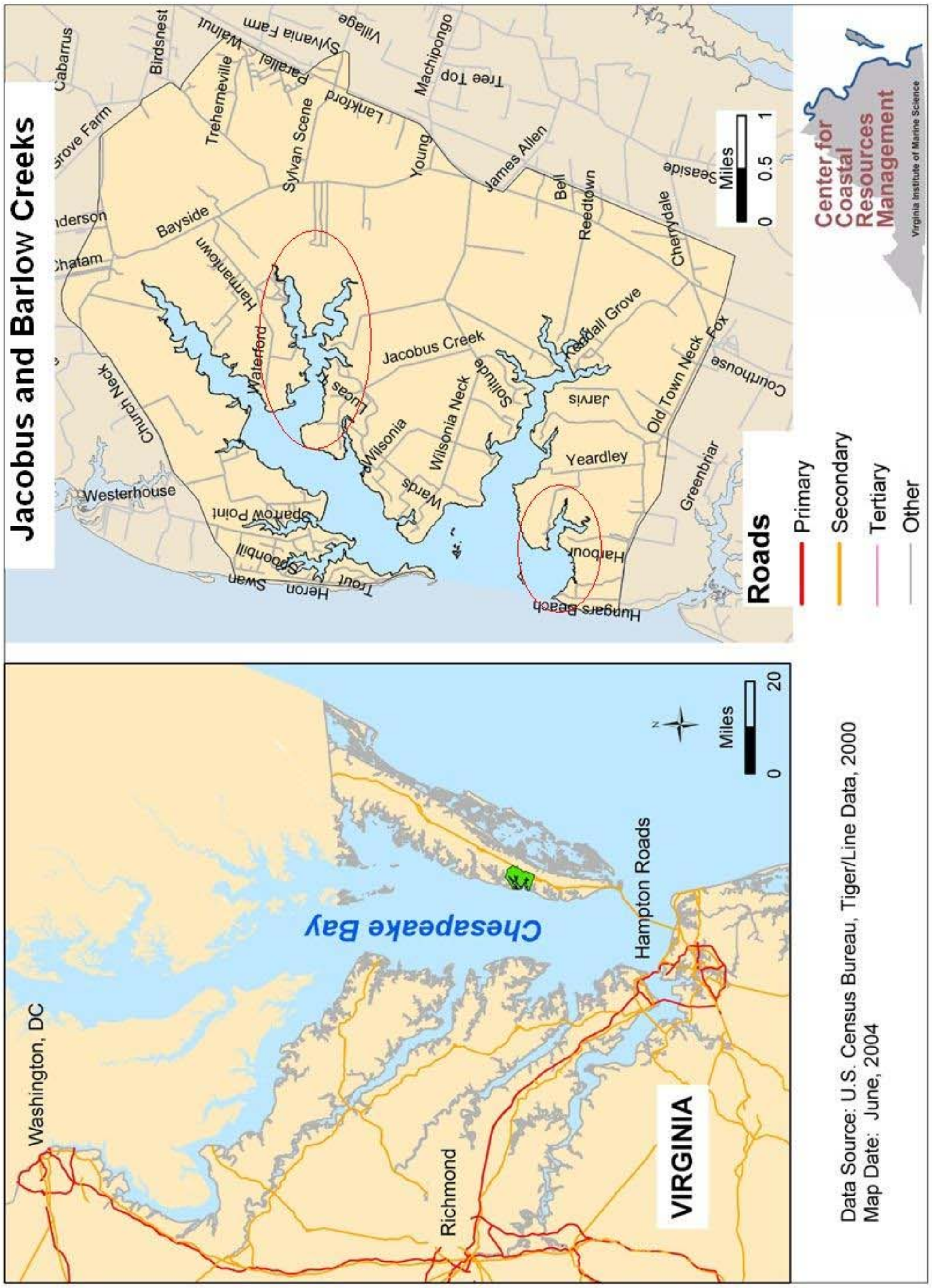

Figure 3.0 Location of the Barlow Creek and Jacobus Creek Watersheds

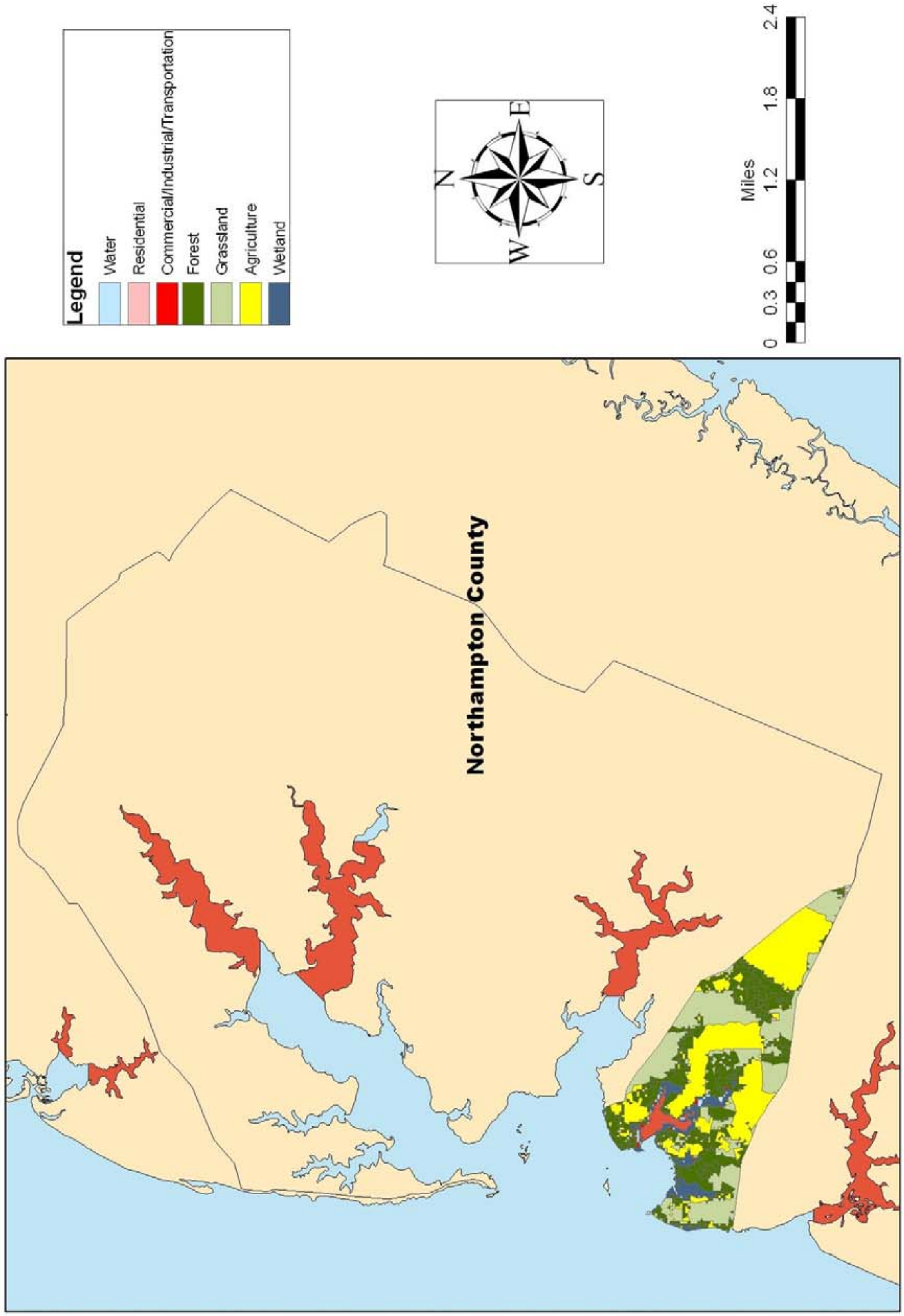

Figure 3.1A Land Use in the Barlow Creek Watershed

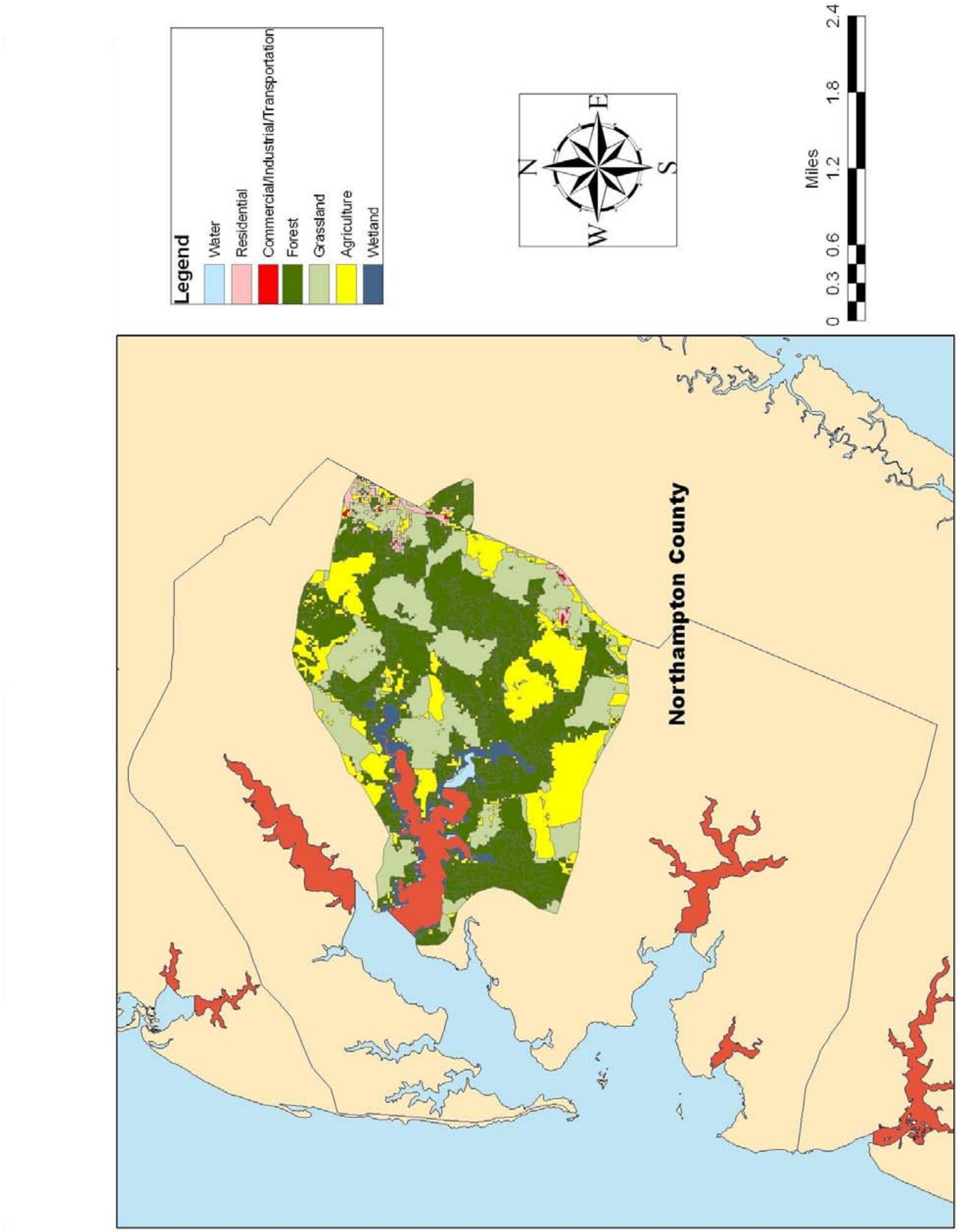

Figure 3.1B Land Use in the Jacobus Creek Watershed

data for the monitoring period of the TMDL study is shown in **Table 4.1**. Graphs depicting the ambient, Geometric Mean, and 90th Percentile bacteria data are shown in **Figures 4.3A through 4.3F**. Stations with the highest levels of fecal coliform bacteria were subjected to a simple regression analysis to examine trends. In each of these watersheds, there is a statistically significant increasing trend in magnitude of exceeding the water quality standard for both Geometric Mean and 90th Percentile for the 30-month period that is the subject of this report. Data for those stations associated with a condemnation from 1998, as indicated by a condemnation number in **Table 4.1** are used for the TMDLs in this study.

The closures in the growing areas are characterized based on all monitoring in the closed area. To facilitate an effective assignment of the appropriate level of protection for this system, the station with the highest water quality data was used to assess the existing load in each condemned area. This provides an increased margin of safety and provides a target that can be easily comprehended and uniformly implemented while retaining the necessary protection for the affected waters.

Table 3.2 Summary of Estimated Land Use in Acres by Type in the Impaired Watersheds of Growing Area 86

Land Use Type	**Barlow Creek 86-136D (VAT-C14E-10)**	**Jacobus Creek 86-136B (formerly segment 9B) (VAT-C14E-12)**
Water	8.0	27.2
Residential	1.5	11.6
Commercial	3.5	13.6
Transitional	0.0	0.0
Forest	352.6	1708.4
Grassland	323.5	1102.8
Agriculture	386.6	956.1
Wetland	62.4	136.8

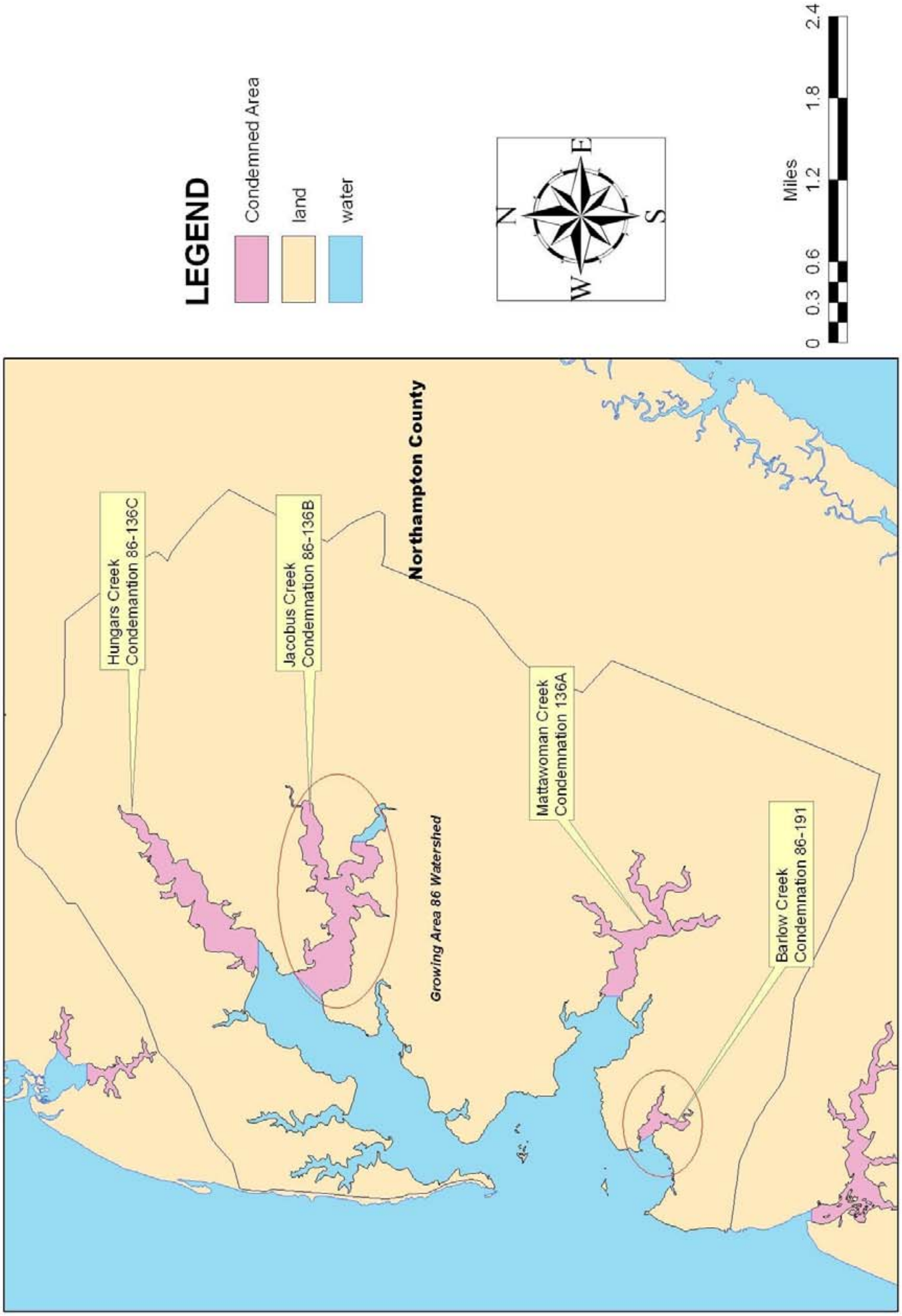

Figure 4.1 Location of Shellfish Condemnation Areas

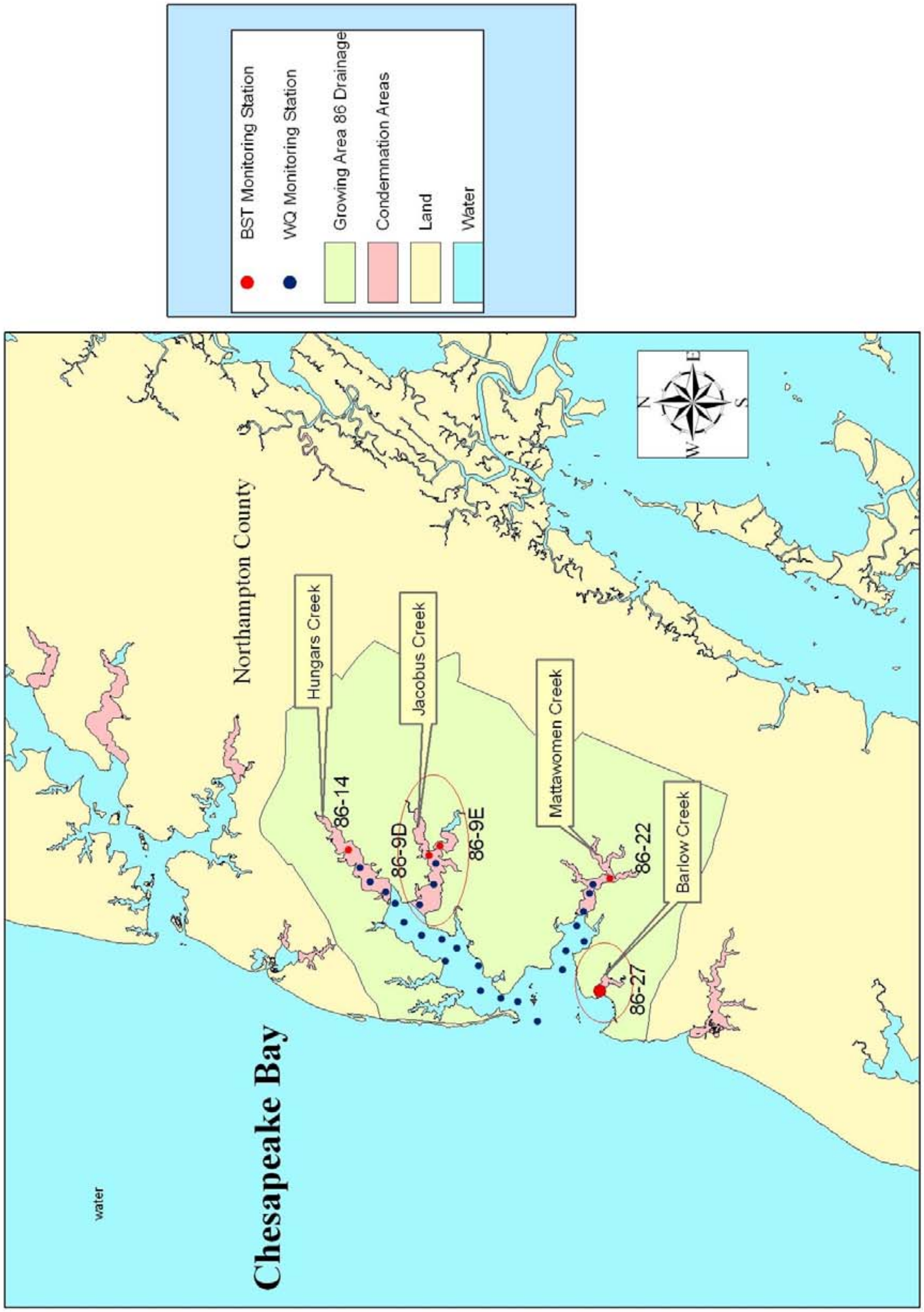

Figure 4.2 Monitoring Stations Located in Growing Area 86

Table 4.1 Water Quality Data Summary: Growing Area 86

Station	Condemnation Area	Total Observations (1/month)	Geometric Mean	Station Violates Geometric Standard: 14 MPN	90th Percentile	Station Violates 90th Percentile Standard: 49 MPN
86-9A	Jacobus Creek 86-136B (VAT-C14E-12)	30	7.4	NO	35.1	NO
86-9B		30	18.1	NO	155.9	YES
86-9C		30	24.7	YES	174.8	YES
86-9D		30	42.9	YES	266.9	YES
86-9E		30	44.9	YES	398.0	YES
86-25	Barlow Creek 86-136D (VAT-C14E-10)	30	4.7	NO	21.5	NO
86-26		30	6.9	NO	22.0	NO
86-27		30	19.4	NO	148.6	YES

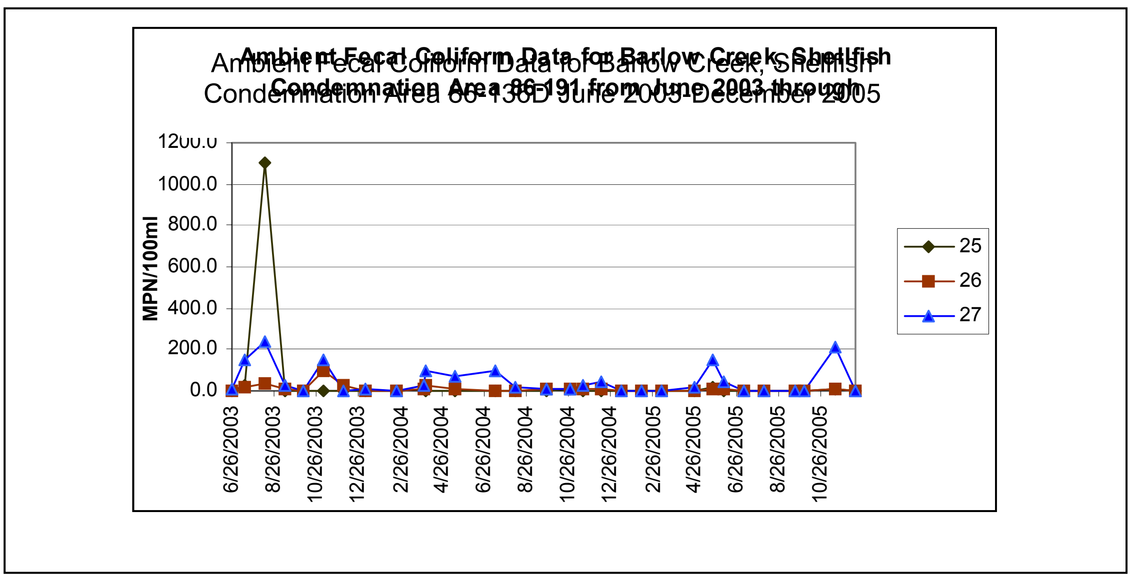

Figure 4.3A Ambient Monitoring Data for Barlow Creek

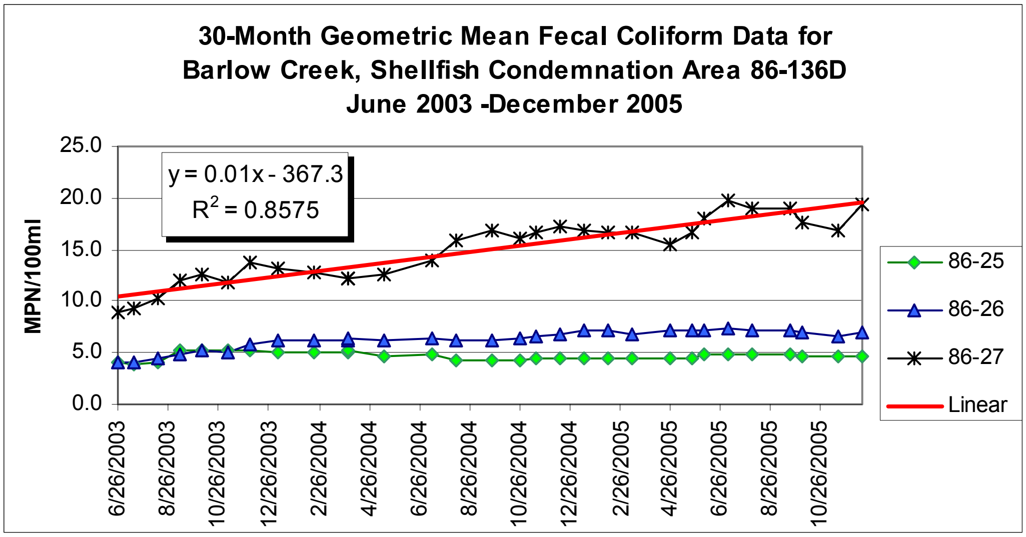

Figure 4.3B 30-Month Geometric Mean Data for Barlow Creek

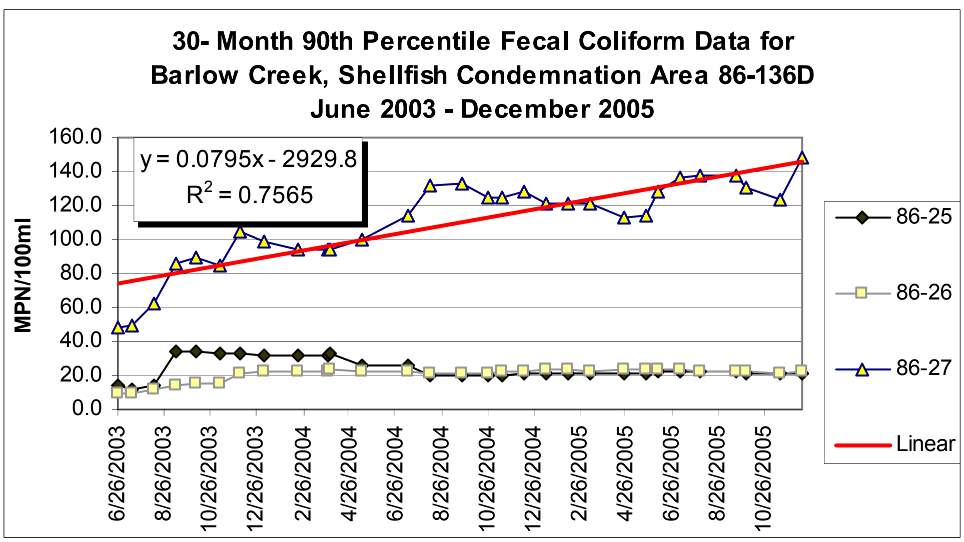

Figure 4.3C 30-Month 90th Percentile Data for Barlow Creek

Figure 4.3D Ambient Monitoring Data for Jacobus Creek

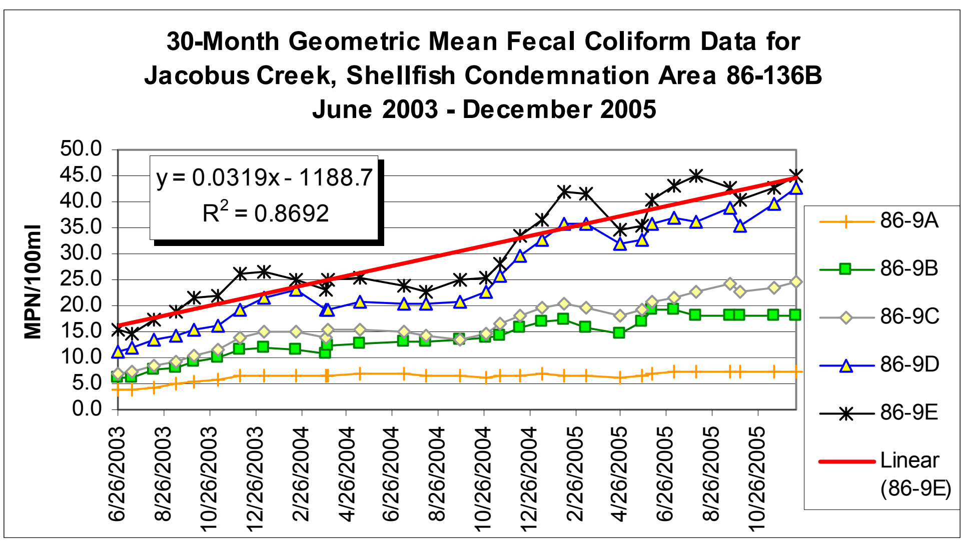

Figure 4.3E 30-Month Geometric Mean Data for Jacobus Creek

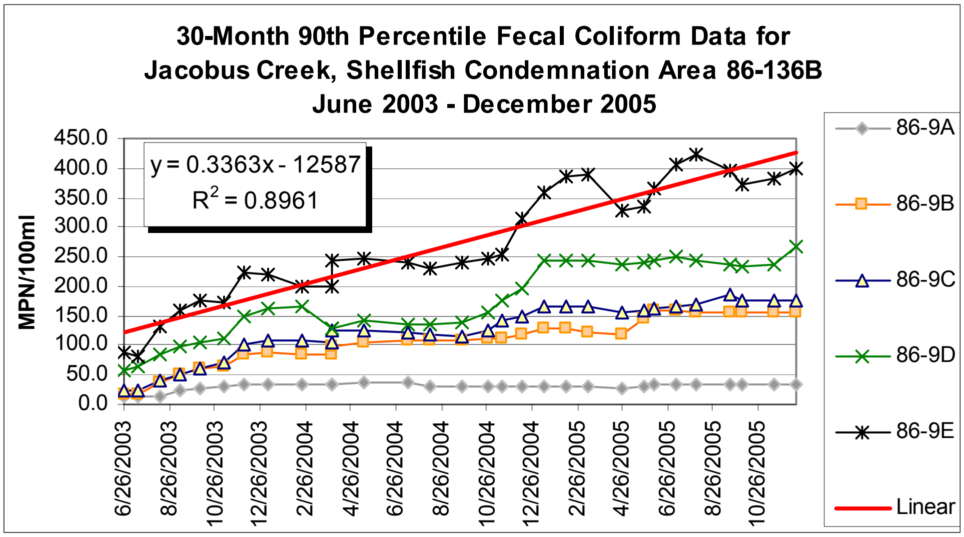

Figure 4.3F 30-Month 90th Percentile Data for Jacobus Creek

4.2 Condemnation Areas

Two impaired segments comprised of portions of Jacobus and Barlow Creeks, in Growing Area 86 were listed as impaired on Virginia's 1998 303(d) list for violations of the water quality standard for fecal coliform bacteria in shellfish supporting waters. These impairments were identified in the 1998 303(d) list as Jacobus Creek **(**VAT-C14E-12) condemnation 86-136B (formerly 9B), and Barlow Creek (VAT-C14E-10) condemnation 86-136D (formerly 191) located in Northampton County, Virginia. Detailed maps of the shellfish condemnation areas and their associated water quality stations are available from VDH-DSS. As previously mentioned, a map of the condemnation areas is shown in **Figure 4.1**. Copies of the current condemnation notice may be found in **Appendix A**.

Under the 1998 303(d) list, two Jacobus Creek segments were listed as impaired, 9B (currently 86-136B) and 9E (currently 86-136E). Section 9E is a permanently prohibited shellfish harvest zone established as a buffer to a facility permitted under the Virginia Pollution Discharge Elimination System (VPDES). These administrative condemnations are never rescinded and result in a removal of the Shellfishing Use for these waters. Under agreement with the United States Environmental Protection Agency (USEPA) Region III, these waters are not considered to be shellfish waters and segment 9E (currently 86-136E) is no longer on the 303(d) list of impaired waters.

4.3 Fecal Coliform Bacteria Source Assessment

The locations of shoreline deficiencies from the DSS shoreline survey are shown in **Figure 4.4**. A copy of the most recent sanitary shoreline survey may be found in **Appendix A**.

A. Point Source

There are no VPDES permitted wastewater treatment plant point source contributions of bacteria to the harvestable shellfish areas in the watershed.

B. Non-Point Source Contributions

Nonpoint sources of fecal coliform do not have one discharge point but may occur over the entire length of the receiving water. Fecal coliform bacteria deposited on the land surface can build up over time. During rain events, surface runoff transports water and sediment and discharges to the waterway. Sources of fecal coliform bacteria include grazing livestock, concentrated animal feeding operations, manure application and wildlife and pet excretion. Direct contribution to the waterway occurs when livestock or wildlife defecate into or immediately adjacent to receiving waters. Nonpoint source contributions from humans generally arise from failing septic systems and associated drain fields, moored or marina vessel discharges, storm water management facilities, pump station failures and ex-filtration from sewer systems. Contributions from wildlife, both mammalian and avian, are a natural condition and may represent a background level of bacterial loading. The water quality data presented in **Figure 4.3A though F** indicates that Jacobus Creek, and to a lesser extent Barlow Creek, are strongly influence by precipitation events. This would indicate that run off from adjacent uplands is conveying bacteria into the aquatic system.

The shoreline survey is used as a tool to identify non-point source contribution problems and locations. **Figure 4.4** shows the results of the VDH-DSS sanitary shoreline survey for January 4, 2006. A copy of the textual portion of this survey has been included as **Appendix A**. The survey identified eight (8) deficiencies. Three (3) were on-site sewage deficiencies, three (3) were related to boating, none were listed for potential pollution, (one) 1 was a solid waste dumpsite, (one) 1 was an industrial site, and none were related to animal pollution. There are no marinas in this watershed and boating activity is restricted to launch and retrieval of boats on trailers.

4.4 Bacterial Source Tracking

Bacterial Source tracking is used to identify sources of fecal contamination from human as well as domestic and wild animals. The BST method used in Virginia is based on the premise that *Escherichia coli (E. coli)* found in human, domestic, and wild animals will have significantly different patterns of resistance to a variety of antibiotics. The Antibiotic Resistance Approach (ARA) uses fecal streptococcus or *E. coli* and patterns of antibiotic resistance for separation of sources of the bacterial contribution. The BST analysis used for this TMDL classified the bacteria into one of four source categories: human, pets, livestock, and wildlife. However, BST analysis is an experimental, not approved, technique that is under evaluation and the error involved in correctly assigning *E. coli* isolates to the appropriate fecal sources is unknown.

Figure 4.2 shows the TMDL study stations in each of the four impaired shellfish growing waters, of which two are Jacobus and Barlow Creeks. There is one BST monitoring station for each of the impaired sub-watersheds. The data developed for the watershed shows the possible dominant anthropogenic bacteria contribution in Barlow and Jacobus Creeks is indicated as a human component followed by livestock and pets. **Figures 4.5A through 4.5C** show the mean distribution by month for the source categories and the annual means are shown in **Figures 4.6A and 4.6B**. **Figure 4.6B** is a composite of two stations in Jacobus Creek. The BST sampling period was October 2003 through September 2004. The target sampling interval was once monthly, if the graph does not show at least 11 months, that means that there were months for which data was not available, or no bacteria could be isolated. This data is shown in **Table 4.2**.

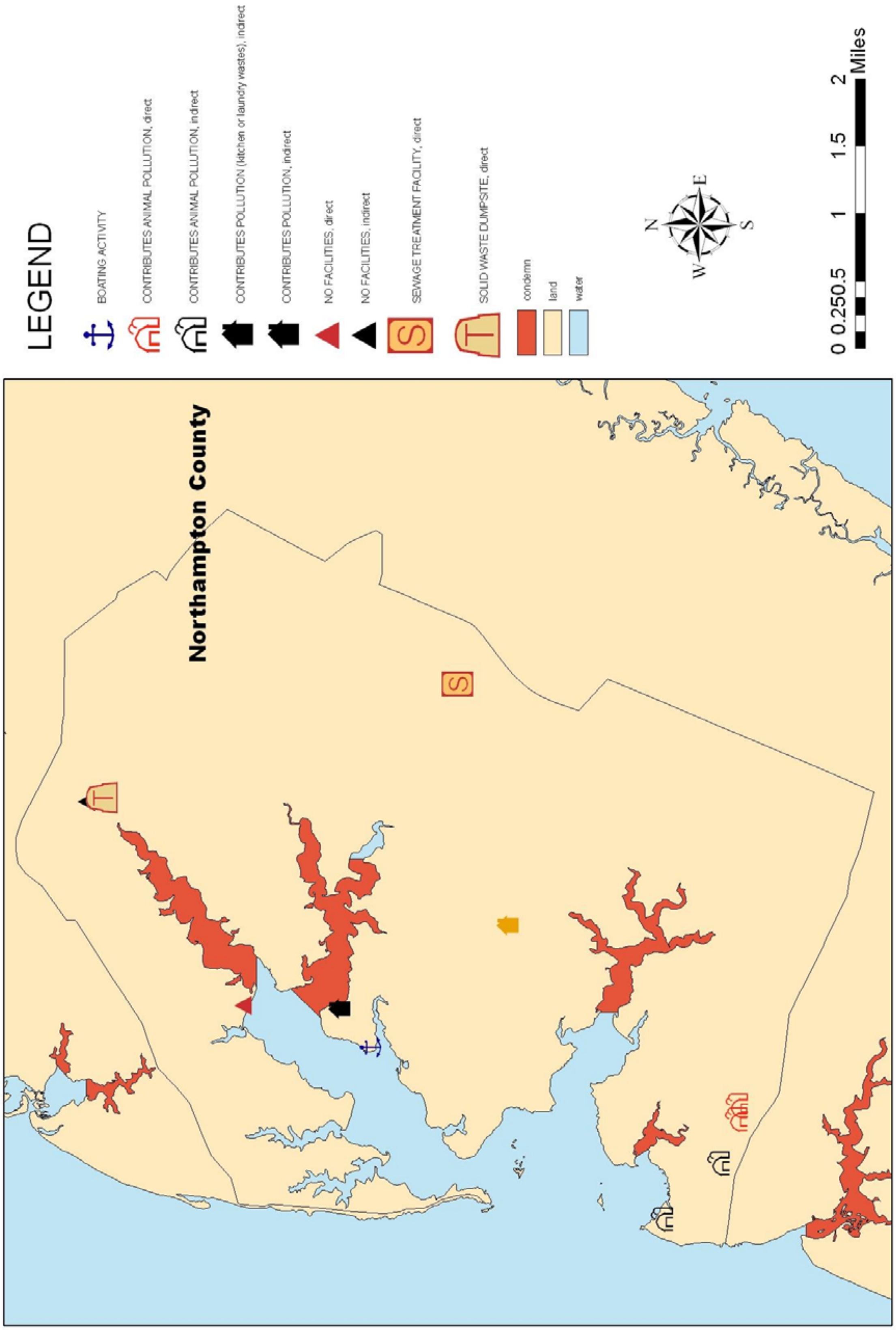

Figure 4.4 VDH-DSS Sanitary Shoreline Survey Results

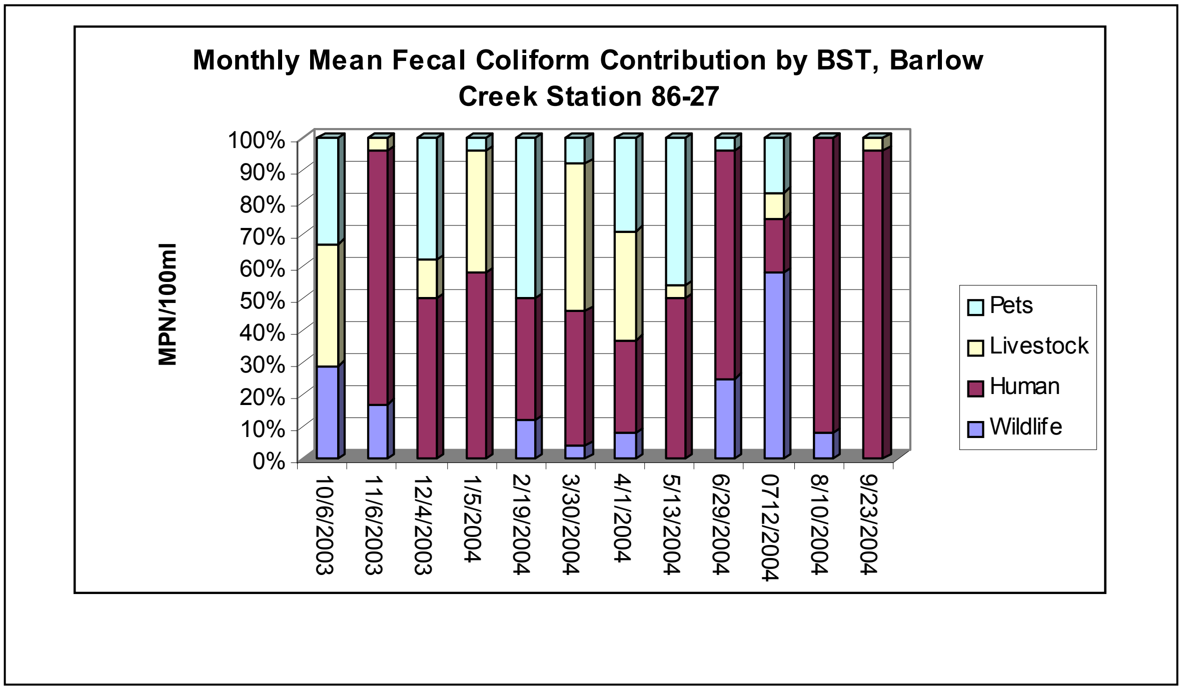

Figure 4.5A Percent Monthly BST Contributions for Barlow Creek

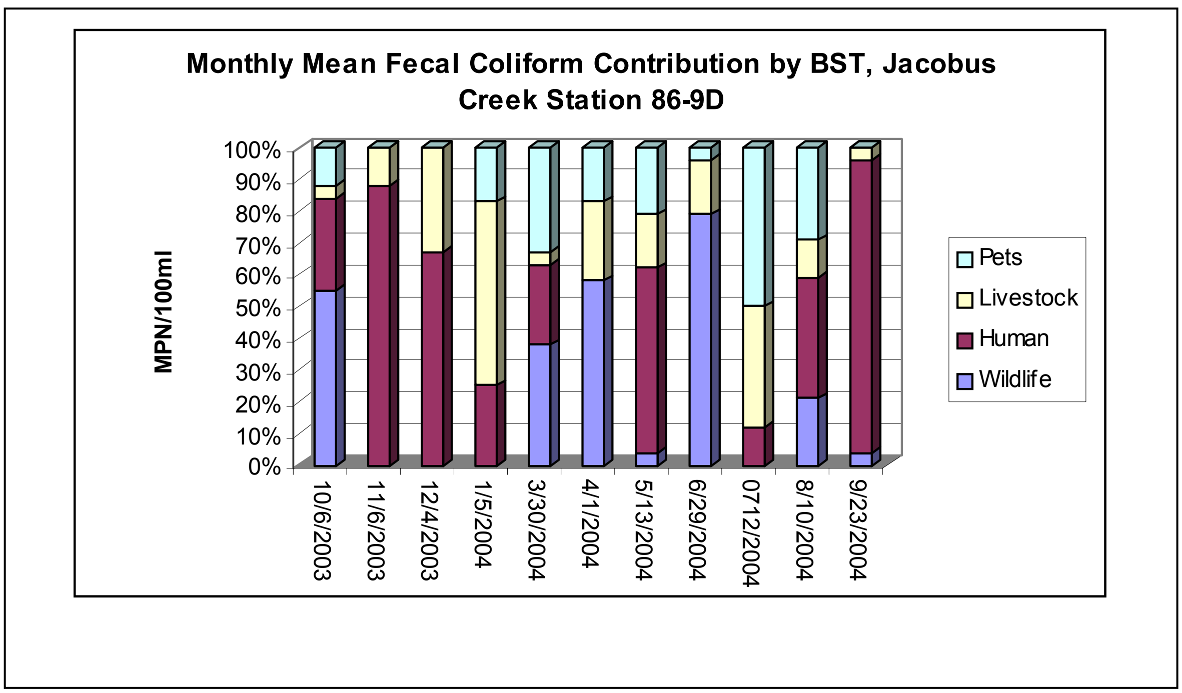

Figure 4.5B Percent Monthly BST Contributions for Jacobus Creek, Station 86-9D

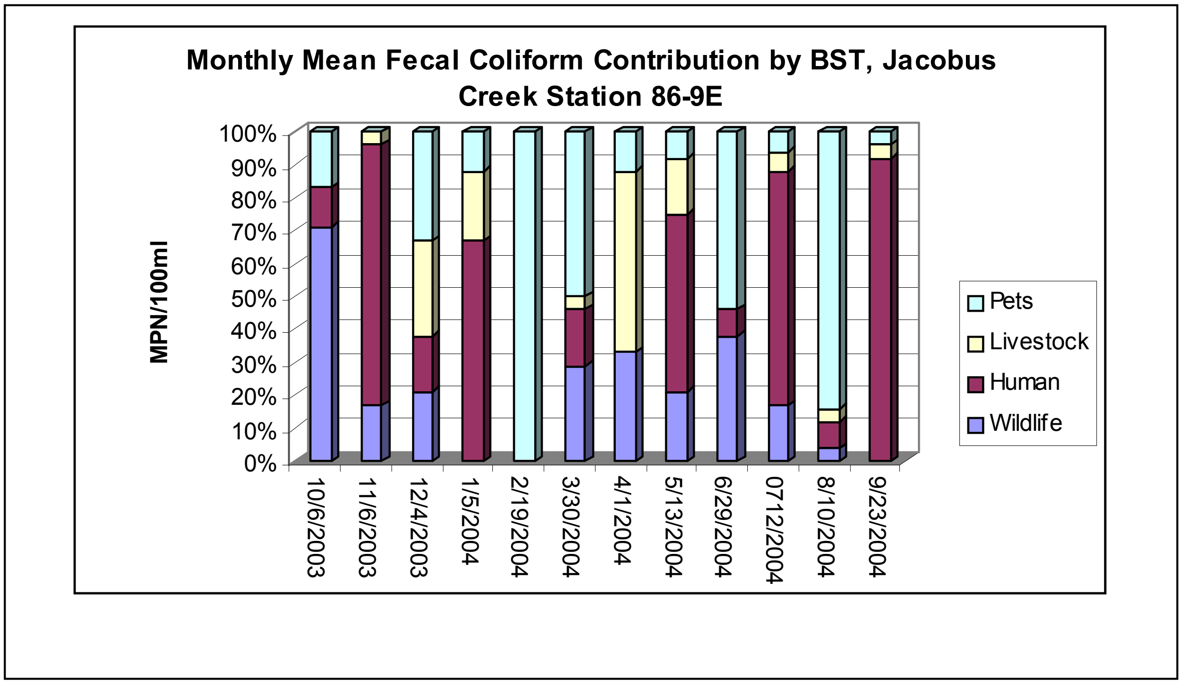

Figure 4.5C Percent Monthly BST Contributions for Jacobus Creek, Station 86-9E

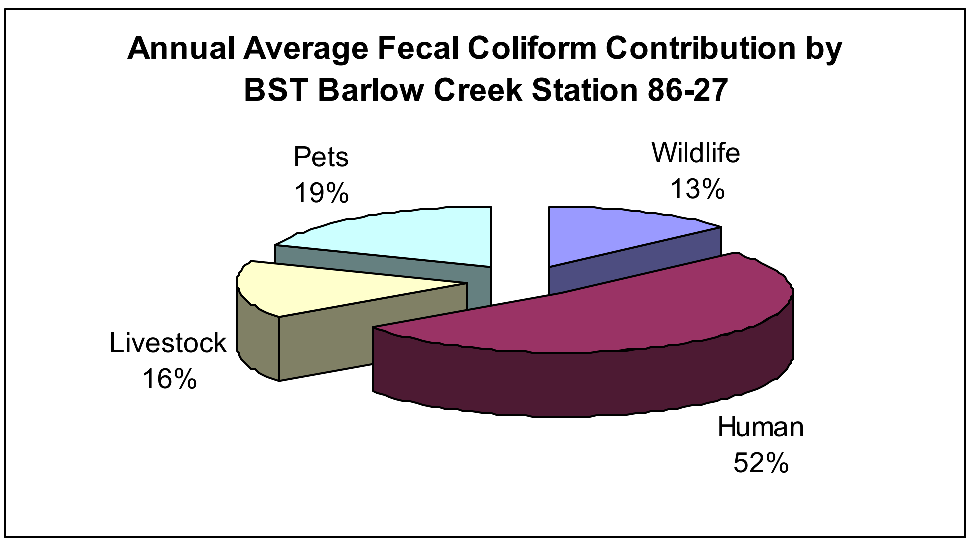

Figure 4.6A Annual Average BST Contributions for Barlow Creek

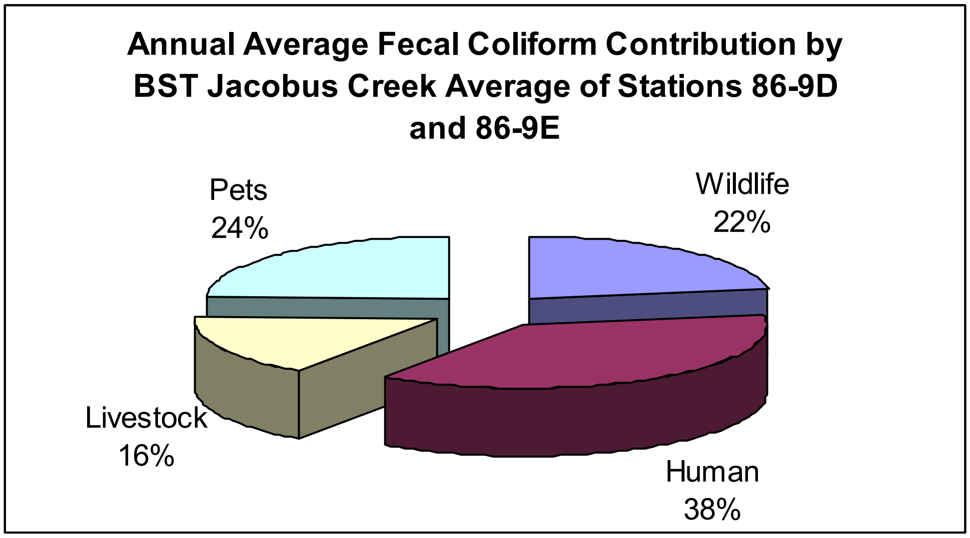

Figure 4.6B Annual Average BST Contributions for Jacobus Creek

Table 4.2 Non-point Source Load Distribution using Annual Average BST; Shellfish Growing Area 86

Condemnation Area	Wildlife	Human	Livestock	Pets
Barlow Creek 86-136D (VAT-C14E-10)	13%	52%	16%	19%
Jacobus Creek 86-136B (VAT-C14E-12)	22%	38%	16%	24%

5.0 TMDL Development

5.1 Simplified Modeling Approach (Volumetric Model):

Personnel from EPA, Virginia DEQ, Virginia DCR, Maryland Department of the Environment (MDE), Virginia VDH-DSS, Virginia Institute of Marine Sciences (VIMS), United States Geological Survey, Virginia Polytechnic University, James Madison University, and Tetra Tech composed the shellfish TMDL workgroup and developed a procedure for developing TMDLs using a simplified approach to the development of the TMDL. The goal of the procedure is to use bacteriological source tracking (BST) data to determine the sources of fecal coliform violations and the load reductions needed to attain the applicable criteria.

5.2 The TMDL Calculation

To meet the water quality standards for both Geometric Mean and 90th Percentile criteria, TMDLs for the impaired segments in the watershed are defined for the Geometric Mean load and the 90th Percentile load. The TMDL for the Geometric Mean essentially represents the allowable average limit and the TMDL for the 90th Percentile is the allowable upper limit.

A. Current Fecal Coliform Condition

The fecal coliform concentration in an embayment varies due to the changes in biological, hydrological and meteorological conditions. The current condition was determined based on the 30-sample Geometric Mean and 90th Percentile of fecal coliform values of each condemned area. The period of record for the monitoring data used to determine the current condition is June 2003 to December 2005. The maximum values for Geometric Mean and 90th Percentile were used to represent the current loads. Therefore, the current loads represent the worse case scenario.

B. Geometric Mean Analysis:

The current 30-sample Geometric Mean was used for the load estimation. The current load was estimated using a simple volumetric model. The allowable load was calculated using the water quality standard of 14 MPN/100ml. This value was also used as boundary condition for the calculation. The load reduction needed for the attainment of the water quality standard was determined by subtracting the allowable load from the current load. The process may be described by the word equation shown below. The calculated results are listed in **Table 5.1**.

The load reduction is estimated as follows:

Geometric Mean Value (X MPN/100ml) x (volume) = Existing Load

Criteria Value (14 MPN/100ml) x (volume) = Allowable Load

$$\textbf{Load Reduction} = \frac{\textbf{Current Load} - \textbf{Allowable Load}}{\textbf{Current Load}} \times 100\ \%$$

Table 5.1 Geometric Mean Analysis of Current Load and Estimated Load Reduction

Condemnation Area	Volume (m^3)	Fecal Coliform (MPN/100ml)	WQ Standard (MPN/100ml)	Current Load (MPN/day)	Allowable Load (MPN/day)	Required Reduction
Barlow Creek 86-136D (VAT-C14E-10)	25560	19.4	14	4.96E+09	3.58E+09	28%
Jacobus Creek 86-136B (VAT-C14E-12)	345960	44.9	14	1.55E+11	4.84E+10	69%

C. 90th Percentile Analysis

The current 30-sample 90th Percentile concentration was used for load estimation. The current load was estimated using a simple volumetric model. The allowable load was calculated based on the water quality standard of 49 MPN/100ml. The calculated results are listed in **Table 5.2**.

The load reduction is estimated as follows:

$$\textbf{Load Reduction} = \frac{\textbf{Current Load} - \textbf{Allowable Load}}{\textbf{Current Load}} \times 100\ \%$$

Table 5.2 90th Percentile Analysis of Current Load and Estimated Load Reductions

Condemnation Area	Volume (m^3)	Fecal Coliform (MPN/100ml)	WQ Standard (MPN/100ml)	Current Load (MPN/day)	Allowable Load (MPN/day)	Required Reduction
Barlow Creek 86-136D (VAT-C14E-10)	25560	148.6	49	3.80E+10	1.25E+10	67%
Jacobus Creek 86-136B (VAT-C14E-12)	345960	398	49	1.38E+12	1.70E+11	88%

5.3 Load Allocation

A comparison of the reductions based on Geometric Mean load and on the 90th Percentile load shows that the 90th Percentile load is the critical condition for all impaired waters in Growing Area 86. This is consistent with water quality analysis. The 90th Percentile criterion is most frequently exceeded. Therefore the 90th Percentile loading is used to allocate source contributions and establish load reduction targets among the various contributing sources that will yield the necessary water quality improvements to attain the water quality standard in the creeks in Growing Area 86.

Based on source assessment of the watershed, the percent loading for each of the major source categories is estimated. These percentages are used to determine where load reductions are needed. The loadings for each source are determined by multiplying the total current and allowable loads by the representative percentage. The percent reduction needed to attain the water quality standard or criterion is allocated to each source category. This is shown in **Table 5.3** and serves to fulfill the TMDL requirements by ensuring that the criterion is attained. The TMDL seeks to eliminate 100% of the human derived fecal component regardless of the allowable load determined through the load allocation process. Human derived fecal coliforms are a serious concern in the estuarine environment and discharge of untreated human waste is precluded by state and federal law. According to the preceding analysis, reduction of the controllable loads; human, livestock and pets, will result in achievement of the water quality standard for all condemned areas except for Jacobus Creek where reductions in wildlife populations are indicted as potentially being necessary to achieve water quality standards. Through an iterative implementation of actions to reduce the controllable loads, subsequent monitoring may indicate that further reductions are not necessary, or that revisions in implementation strategies may be appropriate. Continued violations may result in the process of Use Attainment Analysis, UAA, for the water body (see Chapter 6 for a discussion of UAA). The allocations presented demonstrate how the TMDLs could be implemented to achieve water quality standards; however, the state reserves the right to allocate differently, as long as consistency with the achievement of water quality standards is maintained.

Table 5.3 Reductions and Allocations Based on 90th Percentile Standard Criterion: Growing Area 86

Condemnation Area	Source	BST Allocation % of Total Load	Current Load MPN/ day	Load Allocation MPN/ day	Reduction Needed
Barlow Creek 86-136D (VAT-C14E-10)	Wildlife	13%	4.94E+09	4.94E+09	0%
	Human	52%	1.98E+10	0.00E+00	100%
	Livestock	16%	6.08E+09	3.04E+08	95%
	Pets	19%	7.22E+09	7.22E+09	0%
	Total	**100%**	**3.80E+10**	**1.25E+10**	**67%**
Jacobus Creek 86-136B (VAT-C14E-12)	Wildlife	22%	3.04E+11	1.70E+11	44%
	Human	38%	5.24E+11	0.00E+00	100%
	Livestock	16%	2.21E+11	0.00E+00	100%
	Pets	24%	3.31E+11	0.00E+00	100%
	Total	**100%**	**1.38E+12**	**1.70E+11**	**88%**

5.3.1 Development of Waste Load Allocations

There are no permitted point source discharges that affect the harvestable shellfish waters in the watershed. No waste load allocation is considered in this TMDL.

5.4 Consideration of Critical Conditions and Seasonal Variation

EPA regulations at 40 CFR 130.7 (c) (1) requires TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of the water body is protected during times when they are most vulnerable.
Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards. The current loading to the water body was determined using a long-term record of water quality monitoring (observation) data.

A comparison of the Geometric Mean values and the 90th Percentile values against the water quality criteria will determine which represents the more critical condition or higher percent reduction. If the Geometric Mean values dictate the higher reduction, this suggests that, on average, water sample counts are consistently high with limited variation around the mean. If the 90th Percentile criterion requires a higher reduction, this suggests an occurrence of the high fecal coliform due to the variation of hydrological conditions. For this study, the 90th Percentile criterion is the most critical condition. Thus, the final load reductions determined using the 90th Percentile represents the most stringent conditions and it is the reductions based on these bacterial loadings that will yield attainment of the water quality standard. Seasonal variations involve changes in surface runoff, stream flow, and water quality as a result of hydrologic and climatologic patterns. Variations due to changes in the hydrologic cycle as well as temporal variability in fecal coliform sources, such as migrating duck and goose populations are accounted for by the use of the long-term data record to estimate the current load.

5.5. Margin of Safety

A Margin of Safety (MOS) is required as part of a TMDL in recognition of uncertainties in the understanding and simulation of water quality in natural systems. For example, knowledge is incomplete regarding the exact nature and magnitude of pollutant loads from various sources and the specific impacts of those pollutants on the chemical and biological quality of complex, natural water bodies. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of environmental protection. Due to the very conservative assumptions made in this modeling effort the margin of safety is considered to be implicit in the load allocations the model establishes.

5.6. TMDL Summary

Table 5.4 TMDL Summary for Barlow Creek and Jacobus Creek in Shellfish Growing Area 86 (Geometric Mean)

Condemnation Area	Pollutant Identified	TMDL MPN/100ml	Waste Load Allocation MPN/day	Load Allocation MPN/day	Margin of Safety
Barlow Creek 86-136D (VAT-C14E-10)	Fecal Coliform	14	N/A	3.58E+09	Implicit
Jacobus Creek 86-136B (VAT-C14E-12)	Fecal Coliform	14	N/A	4.84E+10	Implicit

Table 5.5 TMDL Summary for Barlow Creek and Jacobus Creek in Shellfish Growing Area 86 (90^{th} Percentile)

Condemnation Area	Pollutant Identified	TMDL MPN/100ml	Waste Load Allocation MPN/day	Load Allocation MPN/day	Margin of Safety
Barlow Creek 86-136D (VAT-C14E-10)	Fecal Coliform	49	N/A	1.25E+10	Implicit
Jacobus Creek 86-136B (VAT-C14E-12)	Fecal Coliform	49	N/A	1.70E+11	Implicit

6.0 TMDL Implementation

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of that effort for the two bacteria impairments in the Jacobus and Barlow Creek watersheds within Shellfish Growing Area 86. The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan, and to monitor water quality to determine if water quality standards are being attained.

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels in the water body. These measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the recent "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/ipguide.pdf. With successful completion of Implementation plans, Virginia will be well on the way to restoring impaired waters and enhancing the value of this important resource. Additionally, development of an approved implementation plan will improve a locality's chances for obtaining financial and technical assistance during implementation.

6.1 Staged Implementation

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. For example, in agricultural areas of the watershed such as the Barlow and Jacobus Creek watersheds, the most promising management practice is livestock exclusion from water bodies, and control of runoff from pasture and crop lands. This has been shown to be very effective in lowering fecal coliform concentrations in water bodies, both by reducing the cattle deposits themselves and by providing additional riparian buffers.

Additionally, in both urban and rural areas, reducing the human fecal loading from failing septic systems should be a primary implementation focus because of its health implications. This component could be implemented through education on septic tank pump-outs as well as a septic system repair/replacement program and the use of alternative waste treatment systems. In urban areas, reducing the loading from leaking sewer lines could be accomplished through a sanitary sewer inspection and management program.

The iterative implementation of BMPs in the watershed has several benefits:

1. It enables tracking of water quality improvements following BMP implementation through follow-up monitoring;
2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling;
3. It provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements;
4. It helps ensure that the most cost effective practices are implemented first; and
5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan. Specific goals for BMP implementation will be established as part of the implementation plan development.

6.2 Links to On-going Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the Chesapeake Bay. Other TMDLs have been developed for impaired shellfish waters in Northampton County for Nassawadox, Old Plantation, and Cherrystone Creek watersheds. Reports for these TMDLS are available at the Department of Environmental Quality website http://www.deq.virginia.gov/tmdl/. A tributary strategy has been developed for the Virginia tributaries to the Chesapeake Bay. Up-to-date information on tributary strategy development can be found at http://www.snr.virginia.gov/Initiatives/TributaryStrategies.

6.3 Reasonable Assurance for Implementation

6.3.1 Follow-Up Monitoring

VDH-DSS will continue sampling at the established bacteriological monitoring stations in accordance with its shellfish monitoring program. VADEQ will continue to use data from these monitoring stations and related ambient monitoring stations to evaluate improvements in the bacterial community and the effectiveness of TMDL implementation in attainment of the general water quality standard.

6.3.2. Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and waste load allocations can and will be implemented. Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards. Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ also submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

6.3.3. Implementation Funding Sources

One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. Section 319 funding is a major source of funds for Virginia's Non-point Source Management Program.

Other funding sources for implementation include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, the Virginia State Revolving Loan Program, and the Virginia Water Quality Improvement Fund. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

6.3.4 Addressing Wildlife Contributions

In some waters for which TMDLs have been developed, water quality modeling indicates that even after removal of all of the sources of bacteria (other than wildlife), the stream will not attain standards under all flow regimes at all times. **However, neither the Commonwealth of Virginia, nor EPA is proposing the elimination of wildlife to allow for the attainment of water quality standards.** This is obviously an impractical and wholly undesirable action. While managing over-populations of wildlife remains as an option to local stakeholders, the reduction of wildlife or changing a natural background condition is not the intended goal of a TMDL.

Based on the above, EPA and Virginia have developed a TMDL strategy to address the wildlife issue. The first step in this strategy is to develop a reduction goal. The pollutant reductions for the interim goal are applied only to controllable, anthropogenic sources identified in the TMDL, setting aside any control strategies for wildlife. During the first implementation phase, all controllable sources would be reduced to the maximum extent practicable using the staged approach outlined above. Following completion of the first phase, DEQ would re-assess water quality in the stream to determine if the water quality standard is attained. This effort will also evaluate if the technical assumptions were correct. If water quality standards are not being met, a UAA may be initiated to reflect the presence of naturally high bacteria levels due to uncontrollable sources. In some cases, the effort may never have to go to the second phase because the water quality standard exceedances attributed to wildlife may be very small and fall within the margin of error.

If water quality standards are not being met, a special study called a Use Attainability Analysis (UAA) may be initiated to reflect the presence of naturally high bacteria levels due to uncontrollable sources. The outcomes of the UAA may lead to the determination that the designated use(s) of the waters may need to be changed to reflect the attainable use(s). To remove a designated use, the state must demonstrate; 1) that the use is not an existing use, 2) that downstream uses are protected, and 3) that the source of bacterial contamination is natural and uncontrollable by effluent limitations and by implementing cost-effective and reasonable best management practices for non-point source control (9 VAC 25-260-10). All site-specific criteria or designated use changes must be adopted as amendments to the water quality standards regulations. Watershed stakeholders and EPA will be able to provide comment during this process. Additional information can be obtained at http://www.deq.virginia.gov/wqs/WQS03AUG.pdf

7.0. Public Participation

During development of the TMDL for the Barlow Creek and Jacobus Creek in Growing Area 86, public involvement was encouraged through a public participation process that included public meetings and stakeholder meetings.

The first public meeting was held on February 6, 2007. A basic description of the TMDL process and the agencies involved was presented and a discussion was held to regarding the source assessment input, bacterial source tracking, and model results. This meeting was followed by development of the final draft TMDL and a review by the stakeholders. Input from these meetings was utilized in the development of the TMDL and improved confidence in the allocation scenarios and TMDL process.

The second public meeting where the TMDL load allocations were presented was held on April 24, 2007. Public involvement in the TMDL implementation planning process was encouraged.

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8.0 Glossary

303(d). A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.
Allocations. That portion of receiving water's loading capacity attributed to one of its existing or future pollution sources (nonpoint or point) or to natural background sources. (A wasteload allocation [WLA] is that portion of the loading capacity allocated to an existing or future point source, and a load allocation [LA] is that portion allocated to an existing or future nonpoint source or to natural background levels. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading.)
Ambient water quality. Natural concentration of water quality constituents prior to mixing of either point or nonpoint source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.
Anthropogenic. Pertains to the [environmental] influence of human activities.
Bacteria. Single-celled microorganisms. Bacteria of the coliform group are considered the primary indicators of fecal contamination and are often used to assess water quality.
Bacterial source tracking (BST). A collection of scientific methods used to track sources of fecal contamination.
Best management practices (BMPs). Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.
Clean Water Act (CWA). The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.
Concentration. Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).
Contamination. The act of polluting or making impure; any indication of chemical, sediment, or biological impurities.
Cost-share program. A program that allocates project funds to pay a percentage of the cost of constructing or implementing a best management practice. The remainder of the costs is paid by the producer(s).
Critical condition. The critical condition can be thought of as the "worst case" scenario of environmental conditions in the water body in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence.
Designated uses. Those uses specified in water quality standards for each water body or segment whether or not they are being attained.
Domestic wastewater. Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.
Drainage basin. A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.

Existing use. Use actually attained in the water body on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).
Fecal Coliform. Indicator organisms (organisms indicating presence of pathogens) associated with the digestive tract.
Geometric Mean. A measure of the central tendency of a data set that minimizes the effects of extreme values.
GIS. Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)
Infiltration capacity. The capacity of a soil to allow water to infiltrate into or through it during a storm.
Interflow. Runoff that travels just below the surface of the soil.
Loading, Load, Loading rate. The total amount of material (pollutants) entering the system from one or multiple sources; measured as a rate in weight per unit time.
Load allocation (LA). The portion of a receiving waters loading capacity attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished (40 CFR 130.2(g)).
Loading capacity (LC). The greatest amount of loading a water body can receive without violating water quality standards.
Margin of safety (MOS). A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (CWA section 303(d)(1)©). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).
Mean. The sum of the values in a data set divided by the number of values in the data set.
Monitoring. Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.
Narrative criteria. Non-quantitative guidelines that describe the desired water quality goals.
Nonpoint source. Pollution that originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.
Numeric targets. A measurable value determined for the pollutant of concern, which, if achieved, is expected to result in the attainment of water quality standards in the listed water body.
Point source. Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water water body or river.
Pollutant. Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).

Pollution. Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, chemical, and radiological integrity of water.
Privately owned treatment works. Any device or system that is (a) used to treat wastes from any facility whose operator is not the operator of the treatment works and (b) not a publicly owned treatment works.
Public comment period. The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a Federal Register notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).
Publicly owned treatment works (POTW). Any device or system used in the treatment (including recycling and reclamation) of municipal sewage or industrial wastes of a liquid nature that is owned by a state or municipality. This definition includes sewers, pipes, or other conveyances only if they convey wastewater to a POTW providing treatment.
Raw sewage. Untreated municipal sewage.
Receiving waters. Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.
Riparian areas. Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.
Riparian zone. The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.
Runoff. That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.
Septic system. An on-site system designed to treat and dispose of domestic sewage. A typical septic system consists of a tank that receives waste from a residence or business and a drain field or subsurface absorption system consisting of a series of percolation lines for the disposal of the liquid effluent. Solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically.
Sewer. A channel or conduit that carries wastewater and storm water runoff from the source to a treatment plant or receiving stream. Sanitary sewers carry household, industrial, and commercial waste. Storm sewers carry runoff from rain or snow. Combined sewers handle both.
Slope. The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).
Stakeholder. Any person with a vested interest in the TMDL development.
Surface area. The area of the surface of a water body; best measured by planimetry or the use of a geographic information system.
Surface runoff. Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.
Surface water. All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.

Topography. The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.
Total Maximum Daily Load (TMDL). The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.
VADEQ. Virginia Department of Environmental Quality.
VDH. Virginia Department of Health.
Virginia Pollutant Discharge Elimination System (NPDES). The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.
Wasteload allocation (WLA). The portion of a receiving waters' loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation (40 CFR 130.2(h)).
Wastewater. Usually refers to effluent from a sewage treatment plant. See also **Domestic wastewater**.
Wastewater treatment. Chemical, biological, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.
Water quality. The biological, chemical, and physical conditions of a water body. It is a measure of a waterbody's ability to support beneficial uses.
Water quality criteria. Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.
Water quality standard. Law or regulation that consists of the beneficial designated use or uses of a water body, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular water body, and an antidegradation statement.
Watershed. A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.
WQIA. Water Quality Improvement Act.

9.0 Citations

MapTech, Inc. December 2005. Bacterial Source Tracking Analysis to Support Virginia's TMDLs: Shellfish Stations.

US EPA Shellfish Workshop Document (2002).

VA DEQ 1998 303(d) List of Impaired Waters.

10.0 Appendices

Appendix A	Growing Area 86 Sanitary Survey and Condemnation Notices
Appendix B	Supporting Documentation and Watershed Assessment
Appendix C	Code of Virginia *§62.1-194.1* Obstructing or contaminating state waters.

Appendix A: Growing Area 86 - VDH-DSS Shoreline Sanitary Survey

HUNGARS AND MATTAWOMAN CREEKS
Growing Area # 086
Northampton County
Shoreline Sanitary Survey

Date: 4 January 2006
Survey Period: November 15, 2005 – December 20, 2005
Total Number of Properties Surveyed: 335
Surveyed By: S.E. Naylor

SECTION A: GENERAL

This survey area extends from Reference Point 86 at Great Neck Point to Reference Point 87 at Hungars Beach off Route 630, including the Chesapeake Bay shoreline between these two points, Hungars Creek (Paraplane Cove, Jacobus Creek, and Masden Gut), Mattawoman Creek, Barlow Creek and all their tributaries. See map for current survey boundary.

The topography varies in elevation from 5' around the shoreline to a maximum of 25' at the western edge of the survey boundary. The population is generally sparse, except in the neighborhoods of Vaucluse Shores and Hungars Beach. The economy is the area is primarily based on agriculture and the seafood industry.

Meteorological data indicated that 5.01" of rain fell during the survey period. A monthly breakdown follows:

November 15-30 1.87"
December 1-20 3.14"

The current restrictions on shellfish harvesting are Condemned Shellfish Area #136, Hungars and Mattawoman Creeks, revised 31 August 2005. Copies of the current condemnation notice and maps are available via the Internet at http://www.vdh.virginia.gov/oehs/shellfish/.

This report lists only those properties which have a sanitary deficiency or have other environmental significance. "DIRECT" indicates that the significant activity or deficiency has a direct impact on shellfish waters. Individual field forms with full information on properties listed in this report are on file in the Richmond Office of the Division of Shellfish Sanitation and are available for reference until superseded by a subsequent resurvey of the area. Data in the report is also made available to local health departments and other agencies to address items that may be out of compliance with their regulatory programs.

SECTION B: SEWAGE POLLUTION SOURCES

SEWAGE TREATMENT FACILITIES

9. ***DIRECT*** – Occupant: Northampton Middle School, 7207 Young Street, Machipongo, 23405. Owner: Northampton County School Board, PO Box 37, Machipongo 23405. Public school and administration office. 600-650 students/employees. VPDES Permit # VA0023817. Design flow 0.028 MGD. Treatment plant consists of 2 bar screens, influent pump station, stabilization pond, and holding pond. Final effluent is designed to discharge into an unnamed tributary leading to Jacobus Creek. The facility has not discharged for several years. The most recent DEQ inspection report is attached. This facility is located outside of the revised survey boundary, but it may have a direct impact on the headwaters of Jacobus Creek.

ON-SITE SEWAGE DEFICIENCIES

1. CONTRIBUTES POLLUTION – 12117 Trout Lane, Eastville 23347. Dwelling- tan vinyl siding 1 story with white trim. No contact. Broken caps to septic tank cleanout pipes, contents exposed. Sanitary Notice issued 11-16-05 to field # 29.

6. CONTRIBUTES POLLUTION – 14187 Jarvis Lane, Eastville 23347. Dwelling- cream house trailer. 1 person. Effluent erupting from septic tank onto ground surface approximately 100' from Mattawoman Creek at 6' elevation. Sanitary Notice was issued 12-14-05 to field # 278.

8. CONTRIBUTES POLLUTION – 4019 Old Town Neck Drive, Eastville 23347. Dwelling- white wood siding 2 story with red barn. No contact. Unapproved, make-shift wooden lid covering septic tank. Sanitary Notice issued 12-19-05 to field # 297.

POTENTIAL POLLUTION

-None-

SECTION C: NON-SEWAGE WASTE SITES

INDUSTRIAL WASTES

7. 14358 Yardley Road, Eastville 23347. Agriculture- tomato fields with adjacent portable toilets. No contact. Present at time of survey was one 1000 gallon diesel above ground fuel tank without a physical berm.

SOLID WASTE DUMPSITES

3. ***DIRECT*** – Northampton County, Eastville 23347. Public satellite dumpster location. No contact. Observed on-site were 4 trash dumpsters and 5 recycling bins located 50' from Hungars Creek.

SECTION D: BOATING ACTIVITY

MARINAS

-None-

OTHER PLACES WHERE BOATS ARE MOORED

-None

UNDER SURVEILLANCE

2. Vaucluse Shore Association, End of Mallard Lane, Eastville 23347. Private boat ramp and pier. No contact. There were no boats present at time of survey. The only boating service provide was an in-out ramp. Sanitary facilities are provided in residents' private homes. There are no boat holding tank pump-out facilities or dump station facilities provided at this location.

4. Wilsonia Landing Association, 5301 Lucas Trail, Machipongo 23405. Private neighborhood boat ramp and pier. No contact. There were no boats present at time of survey. The only boating service provided was an in-out ramp. Sanitary facilities are provided in residents' private homes. There are no boat holding tank pump-out facilities or dump station facilities provided at this location.

5. Lloyd Outten, End of Wilsonia Harbor Way, Machipongo 23405. Private neighborhood boat ramp and pier. No contact. There were no boats present at time of survey. The only boating service provided was an in-out ramp. Solid waste containers are provided for garbage. Sanitary facilities are provided in residents' private homes. There are no boat holding tank pump-out facilities or dump station facilities provided at this location.

SECTION E: CONTRIBUTES ANIMAL POLLUTION

-None

SUMMARY

Area # 086
Hungars and Mattawoman Creeks
4 January 2006

SECTION B: SEWAGE POLLUTION SOURCES

1. SEWAGE TREATMENT FACILITIES
1 – DIRECT - # 9
0 – INDIRECT – None
1 – B.1. TOTAL

2. ON-SITE SEWAGE DEFICIENCES – Correction of deficiencies in this section is the responsibility of the local health department.
0 – CONTRIBUTES POLLUTION, DIRECT – None
3 – CONTRIBUTES POLLUTION, INDIRECT - # 1, 6, 8
0 – CP (Kitchen or Laundry Wastes), DIRECT – None
0 – CP (Kitchen or Laundry Wastes), INDIRECT – None
0 – NO FACILITIES, DIRECT – None
0 – NO FACILITIES, INDIRECT – None
3 – B.2. TOTAL

3. POTENTIAL POLLUTION – Periodic surveillance of these properties will be maintained to determine any status change.
0 – POTENTIAL POLLUTION – None

SECTION C: NON-SEWAGE WASTE SITES

1. INDUSTRIAL WASTE SITES
0 – DIRECT – None
1 – INDIRECT - # 7
1 – C.1. TOTAL

2. SOLID WASTE DUMPSITES
1 – DIRECT - # 3
0 – INDIRECT – None
1 – C.2. TOTAL

SECTION D: BOATING ACTIVITY

0 – MARINAS – None
0 – OTHER PLACES WHERE BOATS ARE MOORED – None
3 – UNDER SURVEILLANCE - # 2, 4, 5,
3 – D. TOTAL

SECTION E: CONTRIBUTES ANIMAL POLLUTION

0 – DIRECT – None
0 – INDIRECT – None
0 – E. TOTAL

REGISTRAR OF REGULATIONS

08 AUG -6 AM 11: 06

COMMONWEALTH *of* VIRGINIA

Department of Health
DIVISION OF SHELLFISH SANITATION
109 Governor Street, Room 614-B
Richmond, VA 23219

Ph: 804-864-7487
Fax: 804-864-7481

NOTICE AND DESCRIPTION OF SHELLFISH AREA CONDEMNATION NUMBER 086-136, HUNGARS AND MATTAWOMAN CREEKS

EFFECTIVE 19 AUGUST 2008

Pursuant to Title 28.2, Chapter 8, §§28.2-803 through 28.2-808, §32.1-20, and §2.2-4002, B.16 of the *Code of Virginia:*

1. The "Notice and Description of Shellfish Area Condemnation Number 086-136, Hungars and Mattawoman Creeks," effective 20 August 2007, is cancelled effective 19 August 2008.

2. Condemned Shellfish Area Number 086-136, shown as Sections A, B, C, D, and E, is established effective 19 August 2008. As to Sections A, B, C, and D; it shall be unlawful for any person, firm, or corporation to take shellfish from these areas for any purpose, except by permit granted by the Marine Resources Commission, as provided in Section 28.2-810 of the *Code of Virginia*. As to Section E, it shall be unlawful for any person, firm, or corporation to take shellfish from this area for any purpose. The boundaries of these areas are shown on the map titled "Hungars and Mattawoman Creeks, Condemned Shellfish Area Number 086-136, 19 August 2008" which is part of this notice.

3. The Department of Health will receive, consider and respond to petitions by any interested person at any time with respect to reconsideration or revision of this order.

BOUNDARIES OF CONDEMNED AREA NUMBER 086-136

A. The condemned area shall include that portion of Hungars Creek and its tributaries lying upstream of a line drawn between latitude/longitude map coordinate (37°26'04.2", -75°56'32.7") and map coordinate (37°25'59.1",-75°56'31.6").

B. The condemned area shall include that portion of Jacobus Creek and its tributaries lying upstream of a line drawn between latitude/longitude map coordinate (37°25'13.0", -75°56'29.2") and map coordinate (37°25'05.9",-75°56'26.0"); but excluding the area defined as Section E.

C. The condemned area shall include that portion of Mattawoman Creek and its tributaries lying upstream of a line drawn between latitude/longitude map coordinate (37°23'21.0", -75°57'02.5") and map coordinate (37°23'14.4",-75°57'07.1").

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D. The condemned area shall include that portion of Barlow Creek and its tributaries lying upstream of a line drawn between latitude/longitude map coordinate (37°23'12.2", -75°58'24.7") and map coordinate (37°23'07.1",-75°58'23.2").

E. The condemned area shall include that portion of Jacobus Creek and its tributaries lying upstream of a line drawn between latitude/longitude map coordinate (37°25'04.0", -75°56'04.7") and map coordinate (37°24'59.1",-75°56'04.4").

Recommended by: ______________________
Director, Division of Shellfish Sanitation

Ordered by: ______________________ 8/5/06
State Health Commissioner Date


Virginia Department of Health
Hungars and Mattawoman Creeks
Condemned Shellfish Area Number 086-136
19 August 2008
0 1,500 3,000 6,000
Feet
Section A
(37°26'04.2",-75°56'32.7")
(37°25'59.1",-75°56'31.6")
Hungars Creek 11-47-00
Section B
Jacobus Creek 11-47-04
(37°25'13.0",-75°56'29.2")
(37°25'05.9",-75°56'26.0")
(37°25'04.0",-75°56'04.7")
Section E
(37°24'59.1",-75°56'04.4")
Condemned Shellfish Areas (Sections A - D)
Condemned Shellfish Area (Section E)
N
Chesapeake Bay 11-00-00
Northampton County
(37°23'21.0",-75°57'02.5")
Mattawoman Creek 11-49-00
Section C
(37°23'12.2",-75°58'24.7")
(37°23'07.1",-75°58'23.2")
(37°23'14.4",-75°57'07.1")
Section D
Barlow Creek 11-49-02
Geographic coordinates in NAD83 datum; shown in degrees, minutes & seconds.
Swan Dr
Church Neck Rd
Point Rd
Heron Dr
Blue Teal Ln
Trout Ln
Waterford Ln
Harmantown Rd
Lucas Trl
Wilsonia Dr
Wards Rd
Wilsonia Neck Dr
Jacobus Creek Rd
Duckington Ln
Harbour Ln
Yeardley Rd
Oak Grove Rd
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Appendix B: Supporting Documentation and Watershed Assessment

1. Fecal Production Literature Review

2. Geographic Information System Data: Sources and Process

3. Watershed Source Assessment

B-1: Fecal Production Literature Review

	Concentration in feces FC/g	Ref.	Fecal coliform production rate FC/day (seasonal)	Ref.	Comments
Cat	7.9E+06	1	5.0E+09	4	
Dog	2.3E+07	1	5.0E+09	4	
Chicken	1.3E+06	1	1.9E+08	4	
Chicken			2.4E+08	9	
Cow	2.3E+05	1	1.1E+11	4	average of dairy and beef
Beef cattle			5.4E+09	9	
Deer	1.0E+02	6	2.5E+04	6	assume 250 g/day
Deer	?		5.0E+08	9	best prof. judgement
Duck			4.5E+09	4	average of 3 sources
Duck	3.3E+07	1	1.1E+10	9	
Canada Geese			4.9E+10	4	
Canada Geese	3.6E+04	3	9.0E+06	3	
Canada Geese	1.5E+04	8	3.8E+06	8	assume 250 g/day (3)
Horse			4.2E+08	4	
Pig	3.3E+06	1	5.5E+09	4	
Pig			8.9E+09	9	
Sea Gull	3.7E+08	8	3.7E+09	8	assume 10 g/day
Sea gull			1.9E+09	5	mean of four species
Rabbit	2.0E+01	2	?		
Raccoon	1.0E+09	6	1.0E+11	6	assume 100 g/day
Sheep	1.6E+07	1	1.5E+10	4	
Sheep			1.8E+10	9	
Turkey	2.9E+05	1	1.1E+08	4	
Turkey			1.3E+08	9	
Rodent	1.6E+05	1	?		
Muskrat	3.4E+05	6	3.4E+07	6	
Human	1.3E+07	1	2.0E+09	4	
Septage	4.0E+05	7	1.0E+09	7	assume 70/gal/day/person

1. Geldreich, E. and E. A. Kenner. 1969. Concepts of fecal streptococci in stream pollution. J. Wat. Pollut. Control Fed. 41:R336-R352.
2. Geldreich, E., E. C. Best, B. A. Kenner, and D. J. Van Donsel. 1968. The bacteriological aspects of stormwater pollution. J. Wat. Pollut. Control Fed. 40:1861-1872.
3. Hussong, D., J. M. Damare, R. J. Limpert, W. J. L. Sladen, R. M. Weiner, and R. R. Colwell. 1979. Microbial impact of Canada geese (Branta canadensis) and whistling swans.
4. U.S. Environmental Protection Agency. 2001. Protocol for Developing Pathogen TMDLs. EPA 841-R-00-002. Office of Water (4503F), United States Environmental Protection Agency, Washington, DC. 132 pp.
5. Gould, D. J. and M. R. Fletcher. 1978. Gull droppings and their effects on water quality. Wat. Res. 12:665-672.
6. Kator, H. and M. W. Rhodes. 1996. Identification of pollutant sources contributing to degraded sanitary water quality in Taskinas Creek National Estuarine Research Reserve, Virginia. Special Report in Applied Marine Science and Ocean Engineering No. 336, The College of William and Mary, VIMS/School of Marine Science.
7. Kator, H., and M. W. Rhodes. 1991. Evaluation of Bacteroides fragilis bacteriophage, a candidate human-specific indicator of fecal contamination for shellfish-growing waters. A final report prepared under NOAA Cooperative Agreement NA90AA-H-FD234. Prepared and submitted to NOAA, Southeast Fisheries Science Center, Charleston Laboratory, Charleston, SC. 98 pp.
8. Alderisio, K. A. and N. DeLuca. 1999. Seasonal enumeration of fecal coliform bacteria from the feces of ring-billed gulls (Larus delawarensis) and Canada geese (Branta canadensis). Appl. Environ. Microbiol. 65:5628-5630.
9. TMDL report attributed to Metcalf and Eddy 1991 (Potomac Headwaters of West VA).

B-2: Geographic Information System Data: Sources and Process

A geographic information system is a powerful computer software package that can store large amounts of spatially referenced data and associated tabular information. The data layers produced by a GIS can be used for many different tasks, such as generating maps, analyzing results, and modeling processes. Below is a table that lists the data layers that were developed for the watershed and hydrodynamic models.

Table B-2: GIS Data Elements and Sources

Data Element	Source	Date
Watershed boundary	Division of Shellfish Sanitation, VA Department of Health	Various dates
Subwatershed boundary	Center for Coastal Resources Management	2003
Land use	National Land Cover Data set (NLCD), US Geological Survey	1999
Elevation	Digital Elevation Models and Digital Raster Graphs, US Geological Survey	Various dates
Soils	SSURGO and STATSGO, National Resource Conservation Service	Various dates
Stream network	National Hydrography Dataset	1999
Precipitation, temperature, solar radiation, and evapotranspiration	Chesapeake Bay Program, Phase V	2002
Stream flow data	Gauging stations, US Geological Survey	Various dates
Shoreline Sanitary Survey deficiencies	Division of Shellfish Sanitation, VA Department of Health	Various dates
Wastewater treatment plants	VA Department of Environmental Quality	Various dates
Sewers	Division of Shellfish Sanitation, VA Department of Health	Various dates
Dog population	US Census Bureau American Veterinary Association	2000 2002
Domestic livestock	National Agricultural Statistics Service, USDA	1997/2001
Wildlife	Virginia Department of Game and Inland Fisheries, US Fish and Wildlife Service	2004 2004
Septic tanks (from human population)	Division of Shellfish Sanitation, VA Department of Health US Census Bureau	Various dates 2000
Water quality monitoring stations	Division of Shellfish Sanitation, VA Department of Health	Various dates
Water quality segments	Center for Coastal Resources Management	2003
Tidal prism segments	Department of Physical Sciences, VIMS	2003
Water body volumes	Bathymetry from Hydrographic Surveys, National Ocean Service, NOAA	Various dates
Condemnation zones	Division of Shellfish Sanitation, VA Department of Health	Various dates
Tidal data	NOAA tide tables	2004

B-2A: GIS Data Description and Process

Watershed boundary determined by VDH, DSS. There are 105 watersheds in Virginia.

Subwatershed boundaries were delineated based on elevation, using digital 7.5 minute USGS topographic maps. There are 1836 subwatersheds.

The original land use has 15 categories that were combined into 3 categories:
urban (high and low density residential and commercial);
undeveloped (forest and wetlands); and
agriculture (pasture and crops).

Descriptions of Shoreline Sanitary Survey deficiencies are found in each report. Contact DSS for more information. Digital data layer generated by CCRM from hardcopy reports.

Wastewater treatment plant locations were obtained from DEQ and digital data layer was generated by CCRM. Design flow, measured flow, and fecal coliform discharges were obtained from DEQ.

Sewers data layer was digitized from Shoreline Sanitary Surveys by CCRM.

Dog numbers were obtained using the American Vet Associations equation of #households * 0.58.
See website for additional information—
http://www.avma.org/membshp/marketstats/formulas.asp#households1.
Database was generated by CCRM.

Domestic livestock includes cows, pigs, sheep, chickens, turkeys, and horses. Database was generated by CCRM.

Wildlife includes ducks and geese, deer, and raccoons. Animals were chosen based on availability of fecal coliform production rates and population estimates. Database was generated by CCRM.
Ducks and geese–US FWS, DGIF
Deer–DGIF
Raccoons–DGIF

Human input was based on DSS sanitary survey deficiencies and US Census Bureau population data (number of households).

Water quality monitoring data are collected, on average, once per month. Digital data layer of locations was generated by DSS. Water quality data was mathematically processed and input into a database for model use.

Water bodies were divided into segments based on the location of the monitoring stations (midway between stations). If a segment contained >1 station, the FC values were averaged. If a segment contained 0 stations, the value from the closest station(s) was assigned to it. Digital data layer of segments was generated by CCRM. FC loadings in the water were obtained by multiplying FC concentrations by segment volume.

Bathymetry data were used to generate a depth grid that was used to estimate volumes for each water quality segment and tidal prism segment.

The 1998 303d report was used to set the list of condemnation zones that require TMDLs. The digital data layer was generated by CCRM from hardcopy closure reports supplied by DSS.

Population Numbers

The process used to generate population numbers used for the nonpoint source contribution analysis part of the watershed model for the four source categories: human, livestock, pets and wildlife is described for each below.

Human:

The number of people contributing fecal coliform from failing septic tanks were developed in two ways and then compared to determine a final value.

1) Deficiencies (septic failures) from the DSS shoreline surveys were counted for each watershed and multiplied by 3 (average number of people per household).
2) Numbers of households in each watershed were determined from US Census Bureau data. The numbers of households were multiplied by 3 (average number of people per household) to get the total number of people and then multiplied by a septic failure rate* to get number of people contributing fecal coliform from failing septic tanks.

*The septic failure rate was estimated by dividing the number of deficiencies in the watershed by the total households in the watershed. The average septic failure rate was 12% and this was used as the default unless the DSS data indicated that septic failure was higher.

Livestock:

US Census Bureau data was used to calculate the livestock values. The numbers for each type of livestock (cattle, pigs, sheep, chickens (big and small), and horses) were reported by county. Each type of livestock was assigned to the land use(s) it lives on, or contributes to by the application of manure, as follows:

Cattle	cropland and pastureland
Pigs	cropland
Sheep	pastureland
Chickens	cropland
Horses	pastureland

GIS was used to overlay data layers for several steps:

1) The county boundaries and the land uses to get the area of each land use in each county. The number of animals was divided by the area of each land use for the county to get an animal density for each county.
2) The subwatershed boundaries and the land uses to get the area of each land use in each subwatershed.
3) The county boundaries and the subwatershed boundaries to get the area of each county in each subwatershed. If a subwatershed straddled more than one county, the areal proportion of each county in the subwatershed was used to determine the number of animals in the subwatershed.

Using MS Access, for each type of livestock, the animal density by county was multiplied by the area of each land use by county in each subwatershed to get the number of animals in each subwatershed. If more than one county was present in a subwatershed, the previous step was done for each county in the subwatershed, then summed for a total number of animals in the subwatershed. The number of animals in each subwatershed was summed to get the total number of animals in each watershed.

Pets:

The dog population was calculated using a formula for estimating the number of pets using national percentages, reported by the American Veterinary Association:

dogs = # of households * 0.58.

US Census Bureau data provided the number of households by county. The number of dogs per county was divided by the area of the county to get a dog density per county. GIS was used to overlay the subwatershed boundaries with the county boundaries to get the area of each county in a subwatershed. If a subwatershed straddled more than one county, the areal proportion of each county in the subwatershed was calculated. Using MS Access, the area of each county in the subwatershed was multiplied by the dog density per county to get the number of dogs per subwatershed. If more than one county was present in a subwatershed, the previous step was done for each county in the subwatershed, then summed for a total number of dogs in the subwatershed. The number of dogs in each subwatershed was summed to get the total number of dogs in each watershed.

Wildlife:

<u>Deer</u>—

The number of deer were calculated using information supplied by DGIF, consisting of an average deer index by county and the formula:

#deer/mi^2 of deer habitat = (-0.64 + (7.74 * average deer index)).

Deer habitat consists of forests, wetlands, and agricultural lands (crop and pasture). GIS was used to overlay data layers for the following steps:

1) The county boundaries and the subwatershed boundaries to get the area of each county in each subwatershed. If a subwatershed straddled more than one county, the areal proportion of each county in the subwatershed was calculated.
2) The subwatershed boundaries and the deer habitat to get the area of deer habitat in each subwatershed.

Using MS Access, number of deer in each subwatershed were calculated by multiplying the #deer/mi^2 of deer habitat times the area of deer habitat. If more than one county was present in a subwatershed, the previous step was done for each county in the subwatershed, then summed for a total number of deer in the subwatershed. The number of deer in each subwatershed was summed to get the total number of deer in each watershed.

<u>Ducks and Geese</u>—

The data for ducks and geese were divided into summer (April through September) and winter (October through March).

Summer

The summer numbers were obtained from the Breeding Bird Population Survey (US Fish and Wildlife Service) and consisted of bird densities (ducks and geese) for 3 regions: the southside of the James River, the rest of the tidal areas, and the salt marshes in both areas. The number of ducks and geese in the salt marshes were distributed into the other 2 regions based on the areal proportion of salt marshes in them using the National Wetland Inventory data and GIS.

Winter

The winter numbers were obtained from the Mid-Winter Waterfowl Survey (US Fish and Wildlife Service) and consisted of population numbers for ducks and geese in several different areas in the tidal region of Virginia. MS Access was used to calculate the total number of ducks and geese in each area and then these numbers were grouped to match the 2 final regions (Southside and the rest of tidal Virginia) for the summer waterfowl populations. Winter populations were an order of magnitude larger than summer populations.

Data from DGIF showed the spatial distribution of ducks and geese for 1993 and 1994. Using this information and GIS a 250m buffer on each side of the shoreline was generated and contained 80% of the birds. Wider buffers did not incorporate significantly more birds, since they were located too far inland. GIS was used to overlay the buffer and the watershed boundaries to calculate the area of buffer in each watershed. To distribute this information into each subwatershed, GIS was used to calculate the length of shoreline in each subwatershed and the total length of shoreline in the watershed. Dividing the length of shoreline in each subwatershed by the total length of shoreline gives a ratio that was multiplied by the area of the watershed to get an estimate of the area of buffer in each subwatershed. MS Excel was used to multiply the area of buffer in each subwatershed times the total numbers of ducks and geese to get the numbers of ducks and geese in each subwatershed. These numbers were summed to get the total number of ducks and geese in each watershed. To get annual populations, the totals then were divided by 2, since they represent only 6 months of habitation (this reduction underestimates the total annual input from ducks and geese, but is the easiest conservative method to use since the model does not have a way to incorporate the seasonal differences).

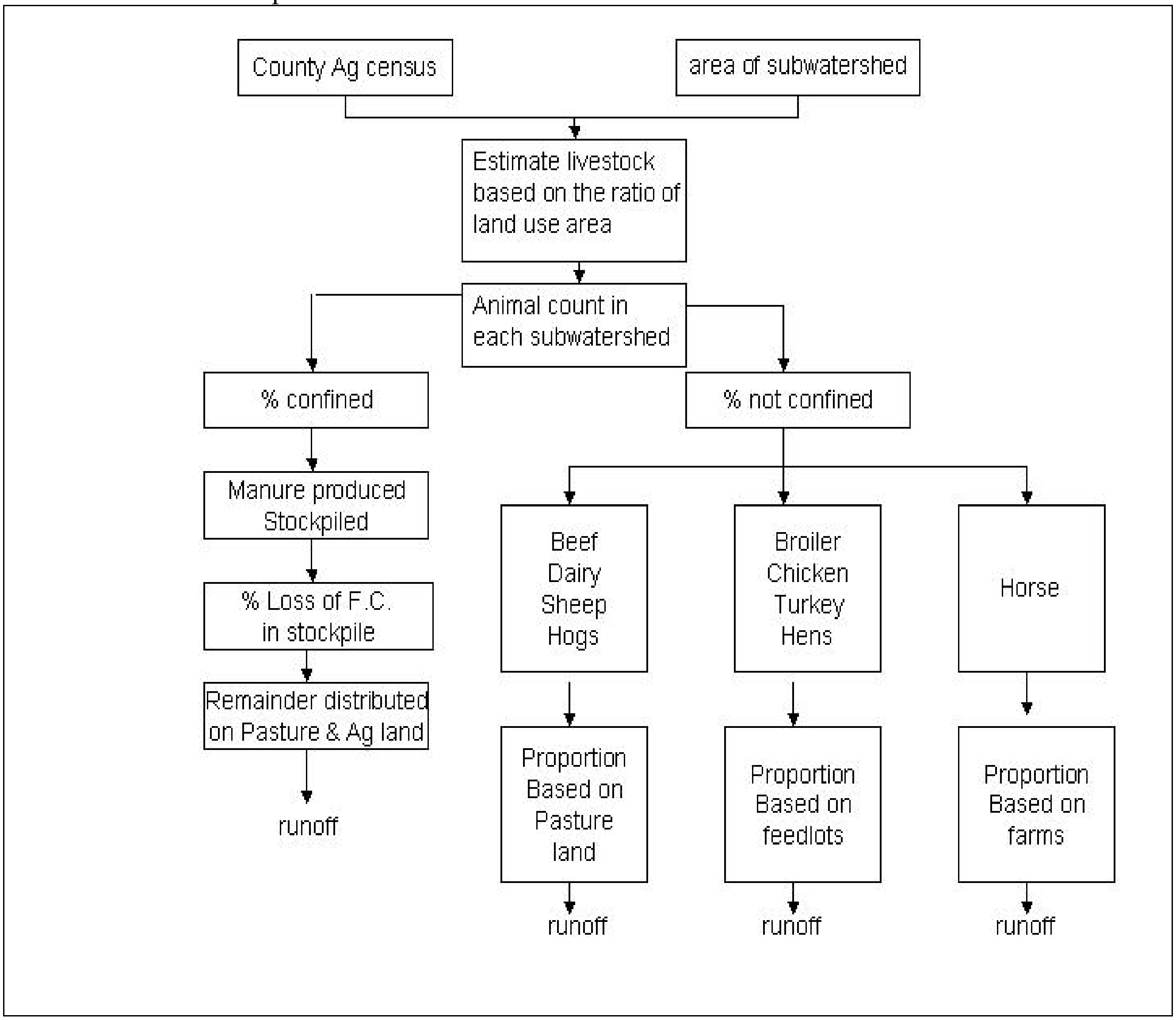
Raccoons—
Estimates for raccoon densities were supplied by DGIF for 3 habitats—wetlands (including freshwater and saltwater, forested and herbaceous), along streams, and upland forests. GIS was used to generate a 600ft buffer around the wetlands and streams, and then to overlay this buffer layer with the subwatershed boundaries to get the area of the buffer in each subwatershed. GIS was used to overlay the forest layer with the subwatershed boundaries to get the area of forest in each subwatershed. MS Access was used to multiply the raccoon densities for each habitat times the area of each habitat in each subwatershed to get the number of raccoons in each habitat in each subwatershed. The number of raccoons in each subwatershed was summed to get the total number of raccoons in each watershed.

B-3: Watershed Source Assessment

The watershed assessment calculates fecal coliform loads by source based on geographic information system data. A geographic information system is a powerful computer software package that can store large amounts of spatially referenced data and associated tabular information. The data layers produced by a GIS can be used for many different tasks, such as generating maps, analyzing results, and modeling processes. The watershed model requires a quantitative assessment of human sewage sources (i. e., malfunctioning septic systems) and animal (livestock, pets and wildlife) fecal sources distributed within each watershed.

The fecal coliform contribution from livestock is through the manure spreading processes and direct deposition during grazing. This contribution was initially estimated based on land use data and the livestock census data. In the model, manure was applied to both cropland and pasture land depending on the grazing period. **Figure B-1** shows a diagram of the procedure for estimating the total number of livestock in the watershed and fecal coliform production. A description of the process used to determine the source population values for wildlife, pets and human used in the calculation of percent loading is found in **Appendix B**.

FIGURE B-3: Diagram to Illustrate Procedure Used to Estimate Fecal Coliform Production from Estimated Livestock Populations



Appendix C: Code of Virginia *§62.1-194.1* Obstructing or Contaminating State Waters

§62.1-194.1. Obstructing or contaminating state waters.

Except as otherwise permitted by law, it shall be unlawful for any person to dump, place or put, or cause to be dumped, placed or put into, upon the banks of or into the channels of any state waters any object or substance, noxious or otherwise, which may reasonably be expected to endanger, obstruct, impede, contaminate or substantially impair the lawful use or enjoyment of such waters and their environs by others. Any person who violates any provision of this law shall be guilty of a misdemeanor and upon conviction be punished by a fine of not less than $100 nor more than $500 or by confinement in jail not more than twelve months or both such fine and imprisonment. Each day that any of said materials or substances so dumped, placed or put, or caused to be dumped, placed or put into, upon the banks of or into the channels of, said streams shall constitute a separate offense and be punished as such. In addition to the foregoing penalties for violation of this law, the judge of the circuit court of the county or corporation court of the city wherein any such violation occurs, whether there be a criminal conviction therefore or not shall, upon a bill in equity, filed by the attorney for the Commonwealth of such county or by any person whose property is damaged or whose property is threatened with damage from any such violation, award an injunction enjoining any violation of this law by any person found by the court in such suit to have violated this law or causing the same to be violated, when made a party defendant to such suit. (1968, c. 659.)